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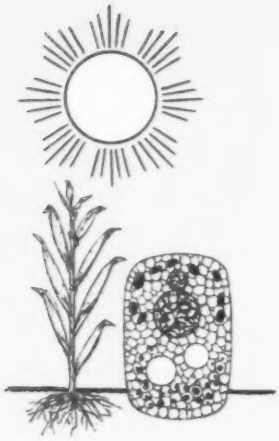

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Some Observations by a Practical Gerontologist

My springboard for this "guest editorial" is "Research on Gerontology" by Dorothy Dickins, which appeared in the 1964 fall number of this journal. Its content may be paraphrased as: Some persons are born old; some achieve old age; some have it thrust upon them.

James Whitcomb Riley's "Grandfather Squeers" had some of the concomitants of age thrust upon him. "So remarkably deaf was my Grandfather Squeers that he had to wear lightning rods over his ears to even hear thunder, and oftentimes then, he was forced to request it to thunder again". But he was not old in spirit. "He said, when he'd rounded his three score and ten, 'I've the hang of it now, and can do it again' ".

The significant distinction between the young and the old is situated not in their bodies but in their minds. The young are alert to ideas; the old are indifferent or mistrustful. But there is impressive evidence that the pleasures of using the mind can continue far beyond any arbitrary age deadline.

Galileo completed his greatest work, "The Two New Sciences," at 72, when old in body and a house prisoner of the Vatican; Nobel Laureates Debye and Giauque, 81 and 70 respectively, are today publishing important research papers; Goethe completed "Faust" at 80; Verdi was 80 when he composed "Falstaff"; Voltaire was 65 when he finished "Candide," his most famous work; Michelangelo was busily occupied as both a sculptor and an architect till his death just short of 90; Bach composed the superb "Musical Offering" at 62.

It is true, as has been asserted, that few scientists do any really creative work after the age of 35. However, only a few do so before the age of 35.

A grandson of mine, about 8 years old, was pouring forth a veritable stream of thoughts and questions. I asked him, "Chris, where do you get all these ideas?" He replied, "When I go to bed I think and I think, and next morning the thinking turns into ideas." Happy indeed is the person who can think and think, and get ideas. I know of no better fountain of youth this.

Joel H. Hildebrand
University of California, Berkeley

THE ANOMIA OF RURAL PEOPLE

ITS MEASUREMENT AND CORRELATES

DANIEL E. ALLEGER

PERSONAL anxiety and despair—termed *anomia* in the social sciences—are characteristics of appreciable numbers of people throughout low-income rural areas of the South. This finding is a by-product of research by the Southern Regional, S–44, Rural Sociology Committee, terminated in 1965 (*3*)[1]. More than half the family heads interviewed during 1960 and 1961 by the S–44 research workers were either anomic, discouraged, or uncertain of the dependability of their social surroundings.

The initial interest of the S–44 committee in anomia centered not specifically upon the nature of anomia but upon the thought that anomia, as a psychological factor, could and probably would influence the way members of families adjust to changing conditions. The committee also reasoned that most families in southern low-income rural regions would have to raise their aspirations dramatically if they were ever to obtain the same level of economic opportunity enjoyed by the average family in the United States. Hence, if it could be ascertained that anomia was a barrier to family adjustment then, presumably, it could also be demonstrated that high levels of anomia would limit the potential effectiveness of rural area development in improving the level of living of rural households.

The primary objectives of the S–44 committee were to determine the relation of various social and personal factors to adjustment and to identify the attitudes, values, and motivations which either facilitate or retard adjustment. In this connection, Mangalam (*9*) reported that "adjustment is looked upon as a process in which the actors and their situations are subject to change. Sometimes the actors, sometimes the situational factors, and often both need to change in relation to each other to bring about adjustment. Delineating value-ends of the given social system at a given time is important in understanding the nature of adjustment." With this appraisal of the adjustment process, interest in the nature and causes of anomia became most appropriate.

[1] Italic numbers in parenthese refer to Literature Cited, p. 9.

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THE NATURE OF ANOMIA

As used herein, *anomia* is a psychological state of mind bordering on uncertainty, hopelessness, and abject despair. This usage differs from the medical view that anomia describes the loss of power to name objects or to recognize names. These two concepts should not be confused.

Whatever its roots, the anomic mentality is, according to Hodges (*8*), "such a blend of insecurity powerlessness, and pessimism" that this blend "comes close to defining what a number of analysts take to be anomia." The anomia of individuals in the low-income rural areas of the southern regions seems to center around one to three personally identified situations: (1) A person thinks his community leaders are indifferent to his needs, (2) he comes to believe that his goal-objectives are eluding his grasp, or (3) he views his immediate personal relationships as no longer being predictive or supportive; or all three may occur together.

To assist research workers and scholars in their search for an understanding of anomia, Clinard in 1964 released an inventory of subject-related studies (1897–1964) prepared by Cole and Zuckerman (*4*). In 1963 Hammonds comprehensively reviewed the concepts of both anomia and its sociological counterpart, anomie (*7*). Although anomia and anomie are clearly interrelated concepts, each retains an individual identity. In this presentation we are concerned with anomia, but when need arises the term *anomie* will be used to describe those social situations characterized by conflicting or lacking social norms. Merton has grasped both the common substance and the interdependence of the two concepts (*12*). He suggests that the higher the degree of anomie in society, the more likely we are to find anomic individuals and the greater the likelihood that individuals will engage in deviant behavior. Since individuals are scored for anomia by the use of psychological scaling instruments, the sums so derived can be aggregated to discover the rates or proportions of individuals in given populations having designated degrees of anomia. These aggregated totals will then essentially constitute indexes of anomie for given social units. By such methods the anomie of southern low-income areas was revealed.

CAUSES OF ANOMIA

In recent years southern rural people have increased their ability to compare their income possibilities with others, both near and far, largely because of the efficacy of modern communication media, and from information of out-migrating sons and daughters. In so doing they have come to recognize that the traditional low-income goal-objectives of yesterday are not compatible with the aspirations of an affluent society. This reaches into the very heart of the present situation and calls for two observations.

> First, this decade is an era of extreme social change in which orientations toward new socially esteemed attainments become clearly formulated.
>
> Second, economic opportunity in each social stratum is theoretically and politically open, but individuals in all strata do not have equal access to opportunity.

By the mid-20th century, city life with its many comforts and conveniences began to dominate all American life. This domination fostered a structure of common life in which the disintegration of traditional rural values became paramount. These values were replaced, at least in part, by anonymity, forfeiture of long-term acquaintanceships, stress on individual achievement, and lack of sympathy for failure. Modern urbanism is the milieu in which secularization is occurring.

Secularization is a process which directs man's attention away from the supernatural and the mythical toward this world and this age. The prime fact about secularization is that it dissolves man's will to believe in the central ideas of his forefathers. It subjects him to social situations which may appear to him as both hostile and unpredictable. Yet before he has had time to adjust to an industrialized and automated occupational structure, computerized automation, called cybernation, is reaching out to further bewilder and handicap him. This would seem to place the relative lot of the low-income southerner in an ever-worsening disadvantaged position. When the social system becomes so structured that access to means of success is seriously restricted, the disjunction between ends and means produces anomia in persons who feel doomed to failure.

The result is that the southern rural countryside

retains for itself high proportions of individuals who have abandoned the effort to create new, respected patterns of daily living. Still, in spite of this abandonment, they reject the structural arrangements of society which require that they accept permanent economic disadvantage as a way of life. By this rejection they become at odds with the highly institutionalized social stratum of which they are a part.

In many areas of the Southern States the Negro, both as farmer and wage-earning nonfarmer, long lived within the same social system as the white but was never effectively a part of it, especially in developing and testing new values and ideals. Although he mastered superior skills in the manual tasks of cultivating cotton and tobacco, however strenuously they were applied, his economic and cultural progress still continued to lag by at least one generation behind that of his white counterparts. To a considerable degree his relatives and friends have deserted the rural countryside for city living. Although he remains on the farm, his level of expectations continues to rise; yet however promising the dawn of morning is in reality, his lack of faith in goal achievement in the morrow is his anomia.

IDENTIFICATION OF ANOMIA

IN 1956 Srole reported to the American Sociological Society on the use of an anomia scale which he had developed (*16*). Although he considered his scale to be but a preliminary model, no other scale has replaced it to date. The original Srole scale was incorporated into the S–44 study, and approximately 2,700 acceptable records of scores, of which 114 were from Floridians, were obtained through its use. This distinction is noted because the Florida project, initiated in 1955, merely contributed to the S–44 regional undertaking. In 1964 it was reported on separately (*1*).

Each postulated component of the scale was so worded that it could be answered either "agree," "disagree," or "no opinion." The scale consisted of five items, which follow:

1. *There's little use writing to public officials because often they aren't really interested in the problems of the average man.* This statement reflected an individual's views on the indifference of community leaders to his needs—the severance of interdependent bonds.

2. *Nowadays a person has to live pretty much for today and let tomorrow take care of itself.* This statement denoted perception of the social order as essentially fickle and unpredictable.

3. *In spite of what some people say, the lot of the average man is getting worse, not better.* This is a statement designed to indicate that the one who agrees feels that he and like people are retrogressing from goals already reached.

4. *It is hardly fair to bring children into the world with the way things look for the future.* This statement measured the attitude that life has little meaning and holds small prospects for one's children.

5. *These days a person doesn't really know on whom he can count.* The implied meaning is that one can no longer rely upon one's associates for social and psychological support—the very rock of social existence.

The S–44 committee modified the Srole scale by adding several additional statements. One of these became the sixth in the scale: *Even if a family objects, a man should choose a job that he thinks is best for him.* This statement measured an individual's attitude toward authoritarianism; that is, toward the belief that the husband-father should have authority over all decisionmaking in family matters, and toward one's blind submission to authority. This did not obscure the reality of the dominance of the female under certain situations.

Scored responses of the male heads to the 5 Srole statements revealed a general acceptance of No. 5

> Rural poverty has proved an almost intractable problem in past decades. Its abolition may require a journey of a thousand miles.
>
> But the first step in that journey is the pooling of the common resources of rural Americans—joining them in a common planning effort that will magnify the resources of each.
>
> President Lyndon B. Johnson
> From a message to the U.S. Congress
> January 25, 1966

(77 percent), which suggested the existence of a common negative attitude toward cohesive factors within the social system. The fact that more than half the respondents accepted statements 1 and 3 implied that they harbored a considerable measure of doubt about the firmness of interdependent community bonds and of the probability of holding fast to goals in life already attained.

The general rejection of statement 4 (63 percent) discloses the measure of faith retained by rural southerners in the meaning of life itself. They seemingly do view the world with considerable optimism in respect to opportunities for their children. This leads one to question the reality of abject despair as a dominant part of the content in the anomia of southern rural individuals. Nevertheless, 4 out of 10 respondents regarded the social order as essentially fickle.

Responses to statement 6 were basically those of agreement (87 percent). This statement, like No. 5, was highly correlated with measurements of anomia. Furthermore, the consistency with which respondents agreed with both statements implied that either statement can be used to evaluate an individual's perception of his immediate personal relationships. Statement 6 should also be valid as a detector of anomia, even though it does not measure it.

SELECTED RESEARCH FINDINGS

SINCE anomia is a psychological factor, it influences the adjustment behavior of individuals. But adjustment is a term both ambiguous and difficult to define, and economists, sociologists, and psychologists each classify the adjustment concept under different frames of reference. Rural sociologists Moon and McCann view it as a state of equilibrium in a sequence of dynamic activity of individuals or groups in a given interactional system (*14*). This definition impiles that, as a family moves from one level of adjustment to another, adjustment is a result of goal-directed rather than random activities and that the process of adjustment is a specific process of social mobility.

Moon and McCann studied the level of adjustment rather than adjustment per se. They examined it by a functional criterion—the extent to which a family has achieved its goals in conformity with the norms and expectations of the society to which it belongs. Related to the functional criterion were six areas: level of living, income, community participation, intrafamily descisionmaking, home and farm tenure, and employment status. They found rural people of the Sandy Coastal Plains to be less anomic and thus presumably better adjusted than adults in other areas. The most handicapped subregion based on the level of adjustment criterion appeared to be the Mississippi Delta. Maladjustment in the Southern Hilly area was also serious. The proportions of the anomic male family heads in the Appalachian Mountains and Border Area (Kentucky, Alabama, and Tennessee) and in the Southern Piedmont and Coastal Plains (Alabama, Louisiana, and North Carolina) were virtually alike, so it is assumed that families were similarly adjusted. But since State boundaries and subregion delineations do not coincide, the proportions of anomic individuals were higher in one State of a subregion than in another State of the same subregion with an assumed diversity in adjustment (*2*).

Using the level of living criterion alone (one of the six levels of adjustment areas used by Moon and McCann), Hammonds found anomia and high socioeconomic status to be inversely related (*7*). So also were anomia and high perception of economic deprivation and high economic status aspirations which family heads held for their sons. These findings simply reinforce other similar discoveries; yet they are significant because they indicate that rural southern people are unwilling to accept, with spiritual equanimity, chronic poverty as their lot in life.

In 1965 Dunkelberger reported to the Association of Southern Agriculture Workers on anomie and aspiration (*5*). The aspiration concept he used was the single-status attribute of occupation-income. It was chosen as a value goal universally accepted by Americans. However, Dunkelberger failed to find analytic support for the theoretical expectation of association between anomie and aspiration. Moreover, he questions whether the anomia of individuals as measured by the S–44 research really indicates despair or simply dissatisfaction. His thinking was partially supported by the general rejection of statement 4 of the Srole scale by S–44 respondents.

Meier and Bell, in a 1959 reappraisal of Srole's findings, suggested that despair—utter hopelessness

and discouragement—was the major part of what the Srole scale actually measured (*11*), "although alienation appears to be measured in some degree as well." Two years later McDill reported that both anomie (or anomia) and authoritarianism were equally important in accounting for intolerant attitudes toward minority groups (*10*). As previously indicated, authoritarianism and unpredictability of immediate personal relationships were highly correlated in the S–44 study.

The linear effects of some 30 independent variables associated with anomia, as determined from S–44 data, were analyzed by Langham and the author in 1965 [2]. Six areas of significance were identified—age, education, employment, income, net worth, and race.

The age distribution of our populations not only is of demographic interest, but also affects our everyday lives. First, ever-increasing proportions of the population reach age 65 as the years go by—approximately a tenth of today's total. Second, rural people handicapped by lack of educational and vocational skills have had to compromise aspirations for independence in old age by dependence upon public assistance for the necessities of life. But far greater mental adjustments are required as changing demands of the labor market effectively bar the unskilled, who are aging, from climbing the ladder of economic opportunity.

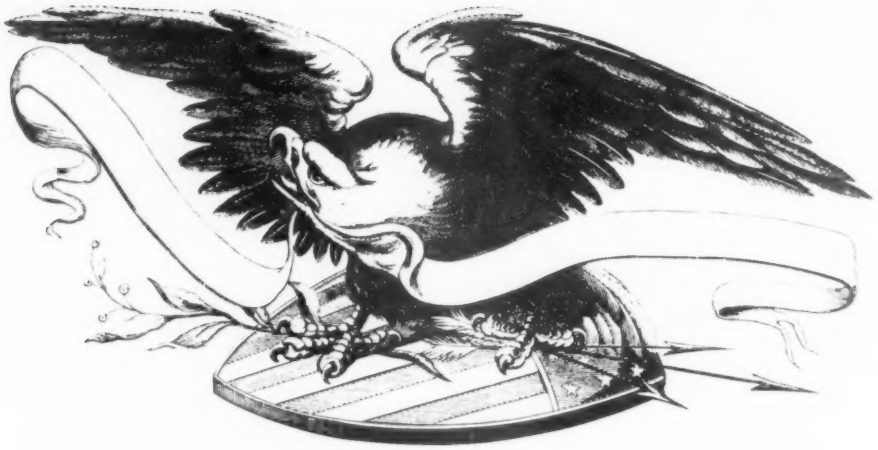
From age 50 upward, as indicated by S–44 data, age is directly related to anomia. Several interpretations can be made from this observation. One is that a person upon reaching age 50 is suddenly confronted with the reality of possible goal-objective defeat, since age is overtaking his speed of progress. Nix (*15*) observed in Alabama that "the increasing comparative disadvantage for those in farming, the increasing ability of low-income families to compare their lot with others, and the general aging of the population in the area" appear to have resulted in a relatively high degree of uncertainty and despair. Another possibility is that the younger people may have a greater adaptability for meeting the impacts of social change as a consequence of having acquired relatively high levels of education and vocational skills.

[2] Alleger, Daniel E., and Langham, Max R., *Anomie in Low-Income Areas of the South*, Unpub. data, Fla. Agr. Exp. Sta., Gainesville, 1965.

The chronic southern low-income areas are usually characterized by (1) high birth rates, (2) inability of people to maintain educational facilities at local expense equal to those of the Nation, and (3) historical realities of development. In subregions of the S–44 study, the average education of farmers in 1960 ranged from 4.3 years in the Mississippi Delta for persons 25 years old or over to 6.8 in the Sandy Coastal Plains (*6*). The average education of the urban adults, in contrast, ranged from 6.0 years in the Mississippi Delta to 8.8 in the Southeastern Hilly section. The rural nonfarm groups fell in intermediate educational ranges.

An encouraging note in the South today is that of all S–44 respondents who had completed 16 years or more of formal education only a negligible percentage was anomic, although relatively low levels of pessimism were evident. By contrast, more than three-fourths of the respondents who had less than 7 years of formal education, or none at all, were either anomic or deeply disenchanted with their environmental situations. The attainment of a college education is, in quantitative terms, the most single significant factor available to people of the rural South for becoming socially well conditioned.[3]

[3] Op. cit.



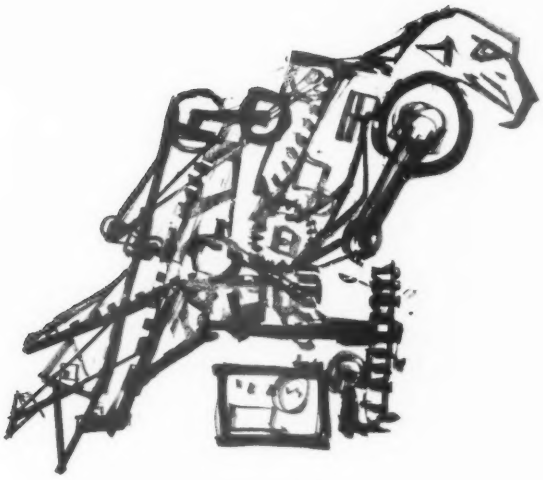
An agrarian economy with its traditional rural values and predictable patterns of living characterized the idyllic past.

One can surmise that educated people find it easier than the poorly educated to migrate to areas of economic opportunities, or to return home when situations are favorable. Out-migrants with low educational attainments, however great the nostalgia for their home areas and however much their aspirations are compromised, generally become frozen in their places of employment through fear of change and from lack of meaningful employment alternatives.

Previous research investigations have demonstrated the existence of associations between social class and anomia. In some of these studies it was assumed that the members of the different social classes have similar life goals (*13*). The S–44 data suggest that respondents in chronically disadvantaged rural areas have relatively modest goal-objectives, as based on satisfaction with occupation, but these may differ from aspirations for the future. Within the occupational structure, employment in sales or clerical capacities was a most positive barrier against anomia, being even quantitatively more important than employment as manager, proprietor, or professional. If this finding is valid, then the rural South might lay stress upon increasing service types of employment opportunities.

One of the apparent paradoxes is that while regular or full-time employment of nonfarmers (40 weeks or more annually) was inversely related to anomia, so also were physical disability and retirement. At least several components seem to be involved in this complex. To the workingman, satisfactory employment means full-time employment. Still, when a worker becomes disabled he may become reconciled to his lot and desist from goal-striving. In part, this is also true of retirement. For the rural retiree, however, agriculture offers opportunities for continued maximization of time and self-direction of effort. The psychological impact of this personal freedom, under conditions of freedom from want, cannot be minimized. Since older rural people tend to be highly anomic, the roots of their despair apparently are anchored to attributes other than retirement.

Employment and income mean different things to different people. Nonfarm gainful workers found annual family incomes of less than $4,000 to be depressive, but farmers accepted annual net farm incomes of $2,000 or more as nonanomic. Still, there is little doubt that nonfarmers, in terms



Automation, cybernation and hostile, unpredictable social situations become the symbolic setting for social anomie.

of household gadgets and material comforts, have higher goal-objectives than farmers. For the farmer, the inability to build up capital assets for farming appears to be the depressive economic factor rather than low income. Net worth of over $4,000 but less than $10,000 was not very acceptable to farmers, but was very much so to nonfarmers.

As the South is generally appraised in historical retrospect, the role of the Negro in these appraisals is variously interpreted. In the Florida zero-one analysis,[4] although nearly a fourth of the Negro male respondents were scored as highly anomic and another 50 percent as anomic to lesser degrees, nevertheless the effect of race on anomia when separately isolated revealed that being a nonwhite did not represent mental tragedy. The anomia of the Negro apparently stems not from race per se but from the social environment which conditions his mental responses. The Negro's probable disadvantages are educational, occupational, and financial. The S–44 data imply that when shortcomings incident to these three factors no longer entrap the Negro, he can accept his position in society, free of anomia, with about the same relative ease as his white neighbor. The process of progress which is emancipatory also produces anomie in society because functional secular restraints (court decisions, national legislation, law enforcement, public opinion, and such) sometimes introduce despair into the social order in terms of world affairs.

It is not enough merely to understand the social forces which overturn the order or system of things. We need to know why some people do not readily adjust to environmental changes, why they halt and stumble before taking any initiative directed toward self-improvement, or why they refuse to take any action at all. Yet, if social situations of life are capable of explanation, then views on how human attitudes can be changed should be forthcoming. The evidence of anomie among rural southerners offers a notion of why some corrective action in respect to life situations is necessary, and a knowledge of the correlates of anomia should suggest what kinds of catalysts are needed to generate acceptable social solutions. Perhaps they can be found by matching types of human desires with useful projects, and, thereby, adequately reward the services of all.

PROGRESS AND PROSPECTS OF THE S–44 PROJECT

PUBLIC programs for betterment can be truly effective only when the goals and objectives of people in any particular area are understood. To prove such an understanding, the S–44 committee established a broad profile of the socioeconomic and sociopsychological characteristics of households of low-income rural areas of the South. These characteristics were placed into mutually exclusive scales and indexes to measure adjustment levels, adjustment potentials, anomia, aspiration, capability to work, communication, dependency, intrafamily decisionmaking, levels of living, and social participation.

The education of the female heads, or homemakers, is one of the most important factors for bringing about family adjustment in the southern rural areas, but the adjustment potentials are limited by the relative old age of household heads and their general lack of formal education. Publications and manuscripts bearing upon these subject matters now total nearly 100. This is the 5-year accomplishment of S–44.

[4] Op. cit.

In 1965 a new research project, S–61, replaced the terminated S–44 project. Under the new project, which is to continue until 1970, an attempt will be made to determine the characteristics of and factors involved in development sequences and decision-making processes of rural southern people. Plans are being formulated to analyze changes in selected areas of human development, factors and conditions involved in physical and social mobility, and social aspirations related to decisionmaking, mobility, and rural youth. From the study just completed and the new one about to begin, a new understanding of the attitudes, aspirations, decisions, and adjustments of rural people of the South should be forthcoming. Such data should aid in the planned transformation of areas of chronic poverty, with its associated mental chaos, into regions of adept people with the capacity to relate positively to social change.

CONCLUSIONS

THE age of the city has come late to the South, but today a tremendous technological system is weaving its rural and urban centers into a common matrix. From this day onward most rural social problems, whatever their nature, must be appraised within an urban framework. One distinguishing hallmark of urbanization is that no man can blame fortune or fate for what he accomplishes or fails to accomplish in this world. Difficulties arise, however, when men try to find acceptable substitutes for accumulated convictions. A key to this difficulty may be goal-striving. In goal-striving, man discovers a unifying thread by which he can fasten esteemed old values to extolled new ones.

The repeated failures of some regions of the United States to capture and hold socially prized goal-objectives may be traced to an agrarian culture, regional folkways, common local loyalties, and

economic and technological deficiencies. Agrarian dominance as an ideology has long since lost its sanction, but tension and unrest have resulted from the intrusion of urbanism. Urbanization demands the separation of residence and employment. It also places institutionalized values upon higher education, and upon skilled manual and mental employments. The lack of preparatory accomplishments for effective competition on the labor market and the apparent hopelessness of succeeding without them give rise to anomia.

The real challenge of the future lies in determining how culturally handicapped individuals can be fitted into meaningful life roles. A college education in the immediate future may be as essential as a high school education today. If computerized automation assumes the magnitude that some of its proponents predict, then the disadvantaged position of some rural areas may intensify. Perhaps, as this research suggests, goal aspirations should be structured to reality, and public-action remedial programs to the realm of probable achievement. By so doing, the causes of anomia, even if not totally eradicated, may be considerably lessened.

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Taste Perception In Animals

MORLEY R. KARE

As the world population continues to expand and as man's food materials become more scarce, interest is being stimulated in finding alternative food sources for animals. This is particularly true in America where animals consume so much food which is also acceptable to humans.

One of the barriers to such effort is the widespread belief that animals share our taste for food. To some extent this belief is exemplified in the feeding of pets. However, even a superficial observer must have some doubts that a coprophagous dog or mouse-eating cat is moved by "home style" or "country flavor" and other qualities designed to appeal to the human palate.

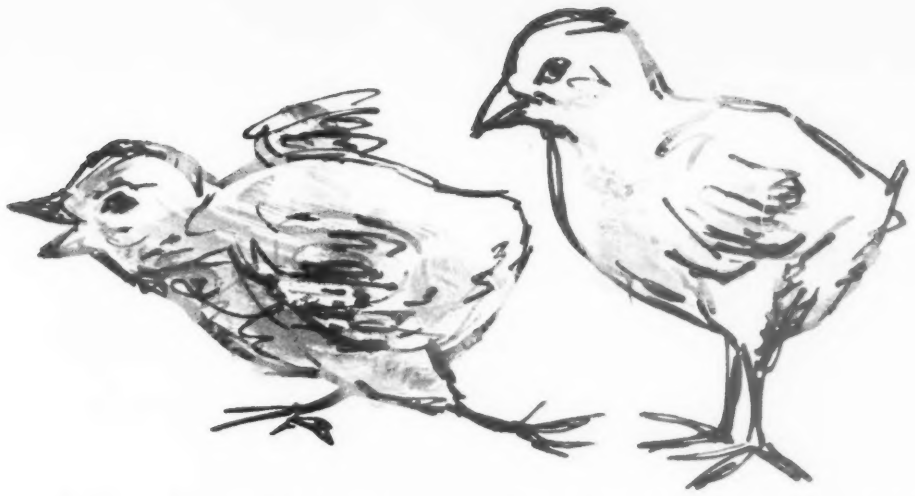
In recent years the character of the sense of taste in a number of domestic animals has been elucidated and it is apparent that they *do not* share man's taste world. Because of this new knowledge gained through research, studies can now be made on the animal's use of food sources hitherto regarded as unpalatable to man. Moreover, such knowledge of taste perception in domestic animals invites a reevaluation of their role as industrial scavengers. A preliminary step, however, is to discard human taste standards in considering food acceptable for animals.

FACTORS GOVERNING CHOICE OF FOOD

A CALF begins life on a high-protein diet, but after a week or two begins to select typical low-protein herbivorous fare. Is taste involved in directing this animal's choice? Does taste lead to or follow the abrupt change in the animal's diet? Changes in diet also occur in birds that are insectivorous part of the year and granivorous during the remainder. Although taste is commonly thought to direct an animal's choice of diet, the scientific evidence for this conclusion is not impressive.

Until recently, our knowledge of taste in animals was limited largely to anecdotal information. It still is generally assumed that animals have a sense of taste similar to that of man, although perhaps more limited in scope. It is true that man has the most highly evolved nervous system; however, animals can and do enjoy sensory mechanisms that can exceed in capacity those experienced by man. A dog can hear sound beyond ranges perceived by man; even a butterfly can perceive sugar solutions a thousand times more dilute than man can perceive. To add insult to injury, the butterfly can do this with its feet. These examples suggest that man must face the fact that he does not represent the ultimate in sensory development.

There is no reason to expect a boa constrictor, an anteater, or man to live in similar sensory worlds. They have very different problems of survival, and one might expect the evolution of specific sensory mechanisms to complement specific needs. For example, consider the tapeworm in its natural habitat—the gut. Obviously, there is little point in its developing an acute sense of hearing: What is there to listen to? Similarly, it does not need a good sense of vision: What has it to see? Although definitive studies have not been made in these areas, the tapeworm might be expected to have a sense of taste. Other animals have developed senses



which will aid them in their struggle for survival. The nocturnal owl depends on hearing to locate its prey, while the rat, also nocturnal, depends on its chemical senses to locate food.

RECEPTOR ORGANS

ALL animals are sensitive to the chemistry of their environment. The withdrawal of the amoeba from acid might be termed primitive chemical perception. The sea anemone responds to tactile and chemical stimuli in distinct and separate sensing areas. Chemical receptors of the fish, although grossly similar to our taste buds, are on the surface of its body. Amphibians can respond to some stimuli applied to their skin; however, they also have orally located taste buds. In contrast, all air-breathing vertebrate animals have their taste buds concentrated in the mouth. The number of taste buds varies widely:

Chicken	24
Pigeon	37
Starling	200
Duck	200
Parrot	350
Kitten	473
Bat	800
Dog	1,706
Man	9,000
Pig and goat	15,000
Rabbit	17,000
Calf	25,000
Catfish	100,000

The meaning of the number of taste buds has not yet been explained; nor does this number necessarily reflect the taste sensitivity of a species. For example, the chicken, which has two dozen taste buds, will reject taste solutions apparently imperceptible to the cow with 25,000 taste buds.

Taste is usually restricted to the sensations produced by gross contact to chemical stimulants as opposed to smell—the "distance receptor"—which is sensitive to volatile substances in extreme dilution. However, all sensations that occur with the ingestion of food are often collectively described as taste, and most people incorporate smell into their conceptions of taste. A variety of factors can modify a taste sensation. Temperature is a particularly interesting variable that we unconsciously consider in our reaction to taste. The taste of some beverages and liquid foods, for example, can be substantially modified by varying the temperature, even though the chemical character of the stimulus does not change. As will be pointed out later, the effect of temperature on taste preference is not restricted to humans.

METHODS OF STUDYING TASTE IN ANIMALS

MAN separates his taste sensations into the classical categories of sweet, sour, bitter, and salty. In animals, however, behavioral taste descriptions are limited to two responses: that which evokes preference or that which evokes offensiveness. The commonest techniques used in studying taste in animals include electrophysiology, conditioning, and measurement of preference.

Electrophysiological techniques for measuring an animal's response to taste stimuli are technically the most sophisticated. The procedure consists of exposing the taste nerve leading to the brain (fig. 1). Various taste stimuli are applied to the tongue, and the electrical information transmitted back to the brain is recorded. We can only determine if the receptor is stimulated, not whether the animal liked or disliked the solution. Despite the fact that evidence can be assembled to relate neural activity and behavior, this relationship is weakened by abrupt contradictions. The calf will respond behaviorally to 1 percent sucrose solution, selecting it exclusively in a choice situation and doubling total fluid intake. Sucrose, however, is an extremely poor electrophysiological stimulant; a 34-percent solution is required for even modest impulse recording. And although sucrose is the most effective sugar in behavioral work with the calf, it is least effective of those studied as electrophysiological stimulants. Similarly, the chicken will drink indifferently sucrose-octa-acetate in solutions which man finds bitter and offensive. However, at this concentration it constitutes a good electrophysiological stimulus.

Conditioning techniques for studying animal taste responses are being used primarily in the U.S.S.R. To illustrate, a calf is given a solution to drink and at the same time is subjected to an electrical shock which causes some physical response such as lifting its leg. The animal learns very quickly to lift its leg and avoid the shock, also to associate the shock with the taste solutions. After the calf is conditioned, application of a shock is unnecessary; the animal automatically lifts its leg when the test solution or anything tasting like the solution is presented to it. Various solutions can then be tested for taste similarity to the test solution.

The most common technique employed in animal studies is the preference test. Usually the animal has two choices of food and the amount it selects from each type is compared. This technique is subject to a wide variety of extraneous factors that qualify the value of the results. For example, if incident light varies between the choices, a rat will discriminate against the choice with the most light, whereas the bird will tend to select the choice with the greatest incident light. The prior experience of the animal, the arrangement of the choices, and a host of other variables—all can modify the response. Also, the final taste of a mixture is not the sum of the component stimulants. One cannot simply add a chemical to a feed to determine the appeal or offensiveness of the chemical. Using human terms, this would be the equivalent of adding chocolate sauce to ice cream and measuring the preference behavior, and then adding chocolate sauce to fish for the same purpose. The impression of chocolate will be influenced by whether it was tried on fish or ice cream.

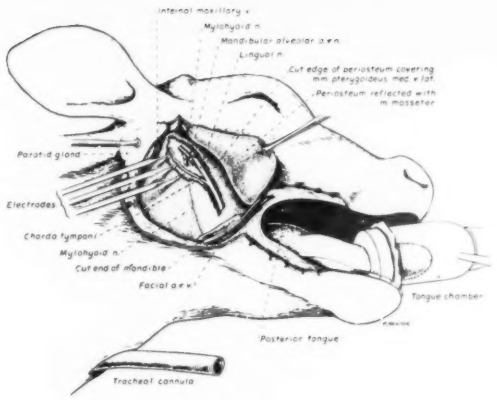


FIGURE 1.—Schematic drawing of the head of a calf preparation showing anatomical landmarks, position of electrodes, and tongue chamber used for flowing the stimulating solutions over the anterior part of the tongue. The right cheek is cut open and sutured to provide access to the posterior part of the tongue. From: Bernard, R. A. *An Electrophysiological Study of Taste Reception in Peripheral Nerves of the Calf. Am. J. Physiol.* 206: 827. 1964.

Many other variables which modify taste reception are peculiar to the species. For example, small differences in temperature of choices could be critical for domestic chickens. They are so sensitive to water temperature that when it is raised to slightly above that of their body (40° C.) they will suffer from acute thirst rather than drink. On the other hand, odor of the choices does not concern the fowl. Some domestic animals (dog, cat, rabbit, and chicken), unlike man, have a water sense—that is, water conveys a taste stimulus. This factor, of course, would complicate the interpretation of response to chemicals tested in aqueous solutions. These examples illustrate that the variables which modify taste in each species must be considered separately for preference tests. This variation compounds the problem of making generalizations on sensory behavior across species boundaries.

SPECIES DIFFERENCES

IT has been commonly misstated that the "sweet tooth" is a universal phenomenon occurring in animals. Part of the explanation for the misunderstanding on perception of sweetness may be that much of the early research work on taste was carried out by psychologists working almost exclusively with rats. We have since observed that the taste response of the rat is uniquely similar to that of man. For example, if we were to prepare a 10-percent solution of sucrose—about equal in sweetness to a cola drink—and an equally sweet solution of saccharine, man would describe both of these as "sweet and pleasant". In our work with animals we have learned that only the rat would find both of these pleasant. The cow would find the sucrose much more appealing than we do, but would be indifferent to the saccharine. The chicken and other birds would be totally indifferent to the sugar solution and would be slightly offended by the saccharine. The dog would respond to the sugar, but many dogs would be considerably offended by the saccharine. Many more examples can be offered to support the conclusion that a "sweet tooth" is not as common a phenomena among animals as was generally thought.

Species difference can be related to specific sugars. For example, in North Carolina tests the cat did not respond to any sugars tested, while the domestic chicken was indifferent to all the common sugars with the single exception of xylose, which it rejected. The calf responded extremely well to dilute solutions of many of the common sugars including xylose, but maltose evoked little or no response. It is interesting that maltose is the most preferred sugar of the rat. One of the sugars which failed to appeal to the rat was lactose. Lactose is selected preferentially by the opossum. It is apparent, therefore, that species differ substantially in their response to sugars. Further, the specific sugar tested can be a critical factor.

Extensive efforts have been made to find something to explain taste behavior in terms of physiological mechanisms. For example, the chick, which is totally indifferent to the common sugars, has a normal blood sugar level almost twice as high as that of man. The cow, which selects sucrose at extremely low concentrations, has a blood sugar of about half that of man; the rat, which selects sucrose at levels appealing to man, has a blood sugar similar to that of man. If research had stopped at that point, it might have been an excellent theory. However—unfortunately for the explanation—the cat has a blood sugar level similar to that of man and is totally indifferent to all the sugars with which it has been tested.

The response of the armadillo to sugar was tested because its milk is reported to contain very little carbohydrate. This animal has a blood sugar level slightly lower than that of man and was found to be indifferent or even offended by some of the common sugars.

INDIVIDUAL AND GENETIC DIFFERENCES

DIFFERENCES in taste between species extend to strains and even to individuals. Pigs from the same litter were tested with saccharine solutions; some were offended by saccharine and some were indifferent, while a majority found the solutions appealing. This finding confirmed casual observations that individual calves and other animals respond differently than the majority to specific stimulants. The response of Japanese quail to various chloride salts was measured. Responses were chemically specific in that the reaction to one chloride bore no relationship as to how an individual quail would respond to a second chloride salt. Samples from a large population of these quail were selected on the basis of high-taste sensitivity or low sensitivity to ferric chloride. Sensitive quail were bred with other sensitive, and nonsensitive with nonsensitive. After rigid selection for five generations, two distinct groups were apparent insofar as degree of response to the iron salt. The fact that this adjustment could occur so quickly raises the question of whether the sense of taste has been modified in the domestic animal. Most of the research on taste has been carried out with domestic or laboratory animals. For these animals, an acute sense of taste has limited survival value, since they have little or no choice of food or fluid. Furthermore, selection in breeding programs has been for qualities such as growth rate, disease resistance, or docility. There is no selection pressure for an acute sense of taste, and it is ignored—if not actually eliminated—as a disadvantage. *Since domestication has resulted in altered anatomical and physiological characteristics, the possibility arises that function and ability to taste have also been altered or even lost.*

WILD VS. DOMESTIC

EXPERIMENTS have been carried out to compare the sense of taste in wild and domestic animals. Both wild and domestic rats exhibited a similar preference for a variety of common sugars. However, the wild rat reacted by increasing its intake only slightly (12 percent) as opposed to the domesticated rats which almost doubled their fluid intake (87 percent). With this increased caloric intake from sugar solutions, the animals ate less of the balanced diet. In the case of xylose (which has a deleterious effect on vision) and nonnutritive saccharine, the wild rat's preference and intake was lower than that of the domestic rat. The results suggest that the wild animal is much more responsive to the nutritional and pathological consequences of its selection and intake, whereas the domestic animal is self-indulgent and more concerned with the hedonic qualities of the available alternatives.

NUTRITIONAL WISDOM

ANIMALS are commonly thought to possess some degree of wisdom to guide them in their selection of food. However, extensive experiments with domestic animals failed to crystalize this contention. Although the domestic chicken rejects xylose solutions which will impair vision, it also rejects nutritious alfalfa. On the other hand, chickens will consume sodium tungstate solutions from a choice situation until they kill themselves; or, if they are vitamin-deficient, they will select thiamine-enriched feed over one devoid of the vitamin. In experiments where feed constituents were replaced with alternatives of lesser or greater nutritional value, the preference reactions of chicks were not consistently an index of the nutritional adequacy of the feed material. In fact, chickens died of protein deficiency even with a dilute casein solution in front of them. Domestic rats were tested in electrophysiological and behavioral trials with a wide variety of amino acids. Included were the so-called essential amino acids, methionine, tryptophane and valine as opposed to the nonessential amino acids, glycine, and alanine. The response magnitude electrophysiologically to the nonessential amino acids was substantially greater than it was for the essential. Also, the animals selected and preferred both nonessential amino acids and found all of the essential amino acids offensive. At least with domestic animals, whether or not an animal prefers a food is not a reliable guide to its nutritional value.

NUTRITIVE STATE

SOME animals will adjust their caloric intake to their needs. When offered a calorically diluted diet they will eat more; or if the diet is enriched, volume intake will be reduced so that caloric intake remains fairly constant.

Addition of quinine to the diet of wild rats failed to alter the caloric intake; however, a similar offensive addition to the food of the domesticated rat substantially reduced intake for a few days. Apparently the domestic rat is much more sensitive to taste than to caloric regulation. An experiment was conducted to compare caloric regulation in the domestic and the jungle fowl. Although normally indifferent to sugar when on a calorically restricted diet, the domestic chicken was observed to select the sugar solution and increase its fluid intake. However, on an enriched diet it failed to respond to the sugar solution and overate. The jungle fowl not only would correct for its caloric deficiency with diluted diets, but did so almost twice as well as did the domestic fowl, and furthermore it corrected for the enriched diet. These experiments indicate that nutritive state will modify taste preference behavior. Moreover, with domestication has come a sluggishness in sensitivity to caloric regulation.

APPLICATIONS IN AGRICULTURE

A MAJOR interest in research on the chemical senses is their possible role in the nutritive processes. The relationship of taste or palatability to hunger, appetite, feed efficiency or satiety has yet to be defined. Food intake, in long-term studies, is remarkably stable despite changes in palatability. For example, food rendered totally unacceptable in a choice situation must have the offensive quality increased tenfold to reduce caloric intake over a period of time in a no-choice situation. However, when food intake is depressed below normal because of such factors as the weaning of domestic animals or a change in environment, highly palatable food can reduce this transitory depression.

Unfortunately the question of what factors influence food intake is clouded by "old wives' tales"

that describe the likes and dislikes of domestic animals. This question has been further complicated by nonsensical "broad spectrum", "miracle flavor" additives which imply that a trace of aromatic essence can shift the basic nervous regulation of food intake.

Knowledge of the chemical senses can aid in solving a variety of agricultural problems. For example, blackbirds, whose numbers far exceed that of people in the United States, consume vast amounts of food, transmit disease, and are the cause of aircraft disasters. Nontoxic chemicals offensive to the taste of these birds but tolerable to ruminants and humans have been identified. It is reasonable to predict that a mastery of the function of the senses in these species will permit us to regulate their movement and feeding activity. Of course, with more knowledge of the senses of other wild species—deer, rabbits, game birds—their territories and feeding habits can be influenced or regulated to our mutual advantage.

Large-scale production requires efficiencies in handling and treating animals. Their reactions to feeding, transportation, and environment have taken on new importance. Self regulation of intake of specific nutrients or medicines is desirable. Knowledge of the sensory mechanism can facilitate these objectives. For example, animals, including the fowl, stop eating but continue to drink when they are ill. For this reason medicines are administered in water. It is not uncommon to find medicines for poultry sweetened with sugar, neutralized, and on occasion even warmed. Our knowledge of the fowl's sensory response would indicate that sugar can be dispensed with, while a low pH and temperature would enhance acceptability.

Although the population explosion is commonly thought of only in terms of pressures on man, it is creating habitat and food problems for animals. Man's activities disturb, to various degrees, the chemical cues in the environment of wild animals. If they are to survive, it is critically important that we come to terms with the wild populations. Understanding their sensory behavior, particularly as it relates to feeding and reproduction, could be most helpful.

Our knowledge of taste is just beginning to enjoy the luxury of systematic investigation. But there are few established physiological and nutritional observations available to explain function. The enigma is complicated by the absence of an overall physical or chemical pattern. Homologous series of compounds, viscosity, optical rotation, and every conceivable parameter have been exhaustively evaluated. However, no single physical or chemical characteristic of the taste stimulants studied could be used reliably to predict animal response.

We know that species differ in their response to taste stimulants and that this variation extends to strains and even individuals. This lack of uniformity, unlike the response to hormones or drugs, is ecologically sound. Imagine the competition for food if all animals had exactly the same sense of taste.

Our research to date clearly demonstrates that animals live in their own sensory world. Man, using his senses, cannot sit in judgment as to what will appeal to or offend an animal. It remains for the agricultural disciplines to direct the accumulation of knowledge on animal senses and apply it for effective use of the world's populations—both man and animal.

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SOME PROBLEMS IN CONDUCTING FLAVOR RESEARCH . . . . .

BOTH the food processor and the consumer are equated by a very important characteristic of food—namely flavor. This characteristic becomes even more important in foods which people consume largely for enjoyment, such as confections. In light of this common interest there has to be a system of communications, and sales figures are certainly a rather expressive and impressive part of the system. This is one important way of measuring the like-dislike aspect of flavor and helping to show when a problem exists. However, such figures are hardly adequate for precisely defining flavor problems or their remedies. Because communication about flavor can often confuse more than it enlightens, perhaps a few terms need to be simply defined.

Flavor has three components: the tactual, the gustatory, and the olfactory. The tactual concerns the way a food feels in the mouth—smooth, grainy, tough, crunchy, etc. The gustatory concerns the limited number of important taste sensations perceived in the mouth—sweet, salty, sour, and bitter. The olfactory involves the aroma or smell of a food. Flavor would be complicated enough if it involved only the tactual and gustatory, but it is the olfactory or aroma dimension that makes variation almost limitless. As a matter of fact, when we talk about flavors we usually are thinking largely in terms of aromas.

One further point about aroma is that it can be perceived in two ways—by tasting and by smelling. Both tasting and smelling can bring aroma (volatiles) laden air up through connected passages to the olfactories lying in the area under the brain. In this latter location the stimulus, in the form of a mixture of volatile molecules, conveys its impression in a way that can be transmited to the brain where it gives the understanding of, say strawberry; or perhaps, strawberry but not very good strawberry—certainly not the kind that grew in anyone's garden. This fantastic process by which a whiff of volatile molecules brushing against a small obscure surface of the body can convey such precise information is still a mystery.

THE THRESHOLD

A WORKING concept which has proven useful in the field of flavor is that of threshold. In brief, this concept states that there is a concentration

(range) of flavor (stimulus) which lies between that which is so dilute it would never be detected and that which is so concentrated it would always be perceived. Thresholds are not precise concentrations and usually the term is defined arbitrarily as that concentration of stimulus which is perceived 50 percent of the time it is applied. A plot of data showing how a threshold can be derived is presented in figure 1. The data are for methyl di-sulfide, a disagreeable-smelling compound with a relatively low threshold (21 p.p.b.).

The concept of threshold interjects the important fact that performance in flavor perception varies between individuals, and with any given individual in relation to many variables. Thus, in flavor research individual judgment is usually avoided in favor of information from a suitable population. The individual may be uniquely different and in certain sense this is true of the expert flavor judge. If the primary objective is high consumer acceptance of a

STUART PATTON, PHILIP G. KEENEY, AND EARL N. BOYD

food item, it might be better to check flavor acceptance with a sample of the consuming public rather than with a flavor expert. As some sage remarked recently: "The flavor expert's opinion is only one statistic." Admittedly, it can be an important one in some circumstances.

The study of flavor thresholds has led to the interesting discovery that they may vary according to the medium in which they are determined. Lea and Swoboda [1] observed that thresholds for a group of aliphatic aldehydes were substantially lower when determined in water as compared with oil. Similar observations have been made for other classes of compounds at various laboratories. More recently, threshold data for fatty acids in oil and water have been compared (table 1). The point of interest about these data is that the effect of the solvent or vehicle on the threshold seems to depend upon the polarity of the compound. The longer chain, more nonpolar acids, exhibited lowest thresholds in water while the short-chain, more polar compounds, yielded lowest thresholds in oil.

[1] Lea, C. H., and Swoboda, P. A. T., *The Flavor of Aliphatic Aldehydes*: Chem. Ind. 1289, 1958.

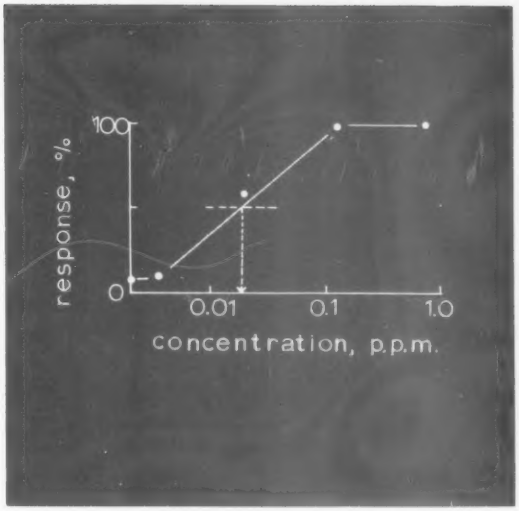

FIGURE 1.—Average flavor threshold data for methyl disulfide in skim milk (five observers used). Data from: *A Method for Determining Significance of Volatile Flavor Compounds in Foods*, Patton S., and Josephson, D. V., Food Research 22:316, 1957.

Simply stated, the principle is that any given flavor (aroma) component may vary in its effectiveness; the variation depends on whether the flavor is carried in a fat or aqueous phase. The practical

TABLE 1.—*Flavor thresholds for volatile fatty acids in water and in oil*

Fatty acid	*Parts per million*	
	Water [1]	*Oil* [2]
C_2	54	.....
C_4	6.8	0.6
C_6	5.4	2.5
C_8	5.8	350
C_{10}	3.5	200
C_{12}	....	700

[1] Patton, S., *Flavor Threshold of Volatile Fatty Acids*, J. Food Sci., 29: 679, 1964.

[2] Feron, R., and Govignon, H., *The Relation of Free Acidity and Taste of Edible Oils*, Ann. Fals. Expert. Chim. 54: 308, 1961.

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implications of this principle are large indeed. Since most flavors are known to be balances of complex mixtures of compounds, anything which alters proportions of components in fat and aqueous phases will change flavor. Ponder for a minute the fact that the flavor (aroma) of some compounds can be detected in water at one one-hundredth the concentration required for detection in a fat or oil; that the converse is true of other compounds; that most flavors contain a host of components and that for many of the highly desirable natural favors, definite distribution ratios between fat and aqueous phases may be characteristic. Undoubtedly, this is one reason why chemical characterization of volatiles is only part of the answer to understanding and mastery of natural flavors.

A few postulations that stem from the foregoing principle follow:

(*a*) The quality and intensity of an added flavor will depend on whether it is added to the fat or the aqueous phase of a food system.

(*b*) Homogenization of a fat-containing food will modify flavor by increasing the surface area between the phases.

(*c*) Since solubility is a function of temperature, processing and storage temperatures may influence flavor through distribution equilibria between fat and aqueous phases.

(*d*) The preceding item probably explains why storage periods to even out flavors (such as vanilla in ice cream) are required.

(*e*) Likewise, dehydrated foods will require time to achieve equilibrium after reconstitution with water and may never achieve quite the same distribution as that in the pre-dried state.

CHEMICAL CHARACTERIZATION OF NATURAL FLAVORS

ONE facet of scientific progress concerns its revelation of how complex things are. This matter was described recently as "the ever-widening darkness." In some respects this defines the present state of research on the chemistry of natural flavors. More specifically, the newer analytical techniques, particularly those involving chromatography, have enabled separation of very minute amounts of complex mixtures into individual components with great efficiency. The behavior of individual components in these chromatographic systems has provided some evidence for identification, and where this evidence has proven inadequate, an array of modern instruments stands ready to aid the cause. These include the mass spectrometer, the nuclear magnetic resonance spectrometer and the various radiant energy spectrophotometers (infrared, etc.)—all yielding evidence of structure or function and thus identity. The principal separation techniques are gas (GC) and thin-layer (TLC) chromatography.

In a sense it would seem that all these instruments and techniques were specially developed for the flavor field because they are so admirably suited to the problems—separation and identification of volatile mixtures in very small quantities. However, most of the techniques and instruments have been used for 10 years or longer and it is generally agreed that the first natural flavor is yet to be fully and adequately characterized. At the very least it can be said that the synthetics developed thus far have not yet pushed the great natural flavors (chocolate, vanilla, coffee, fruits, meats, and dairy products flavors) from the marketplace.

What is the reason, then, for this apparent lack of progress in the characterization of nautral flavors? Partly, it seems due to the delicacies of the way individual components of a flavor may behave in the particular food system—the variation previously mentioned between lipid and aqueous systems and as yet uncharacterized associations of volatile components with each other and with their environments. But in large measure the problem results from the complexity that has been met in the make-up of the natural flavors. Some penetrating minds may have surmised that fact long ago, but GC has made it abundantly clear. Chocolate is a prime example of this. Consider the gas chromatogram of chocolate (distillate from liquor) volatiles shown in figure 2. This is a fairly good separation for a packed column and shows over 40 components. There is reason to believe that there are many more than 40 components in chocolate volatiles. Some peaks in the chromatogram due to incomplete resolution contain at least several components.

Other compounds of importance are not present insufficient quantity to produce a peak at the sensitivity setting used in obtaining the data. This brings up the important point that the detectors used in gas chromatography are not precisely right for flavor research. Most GC detectors respond to the amount of a component irrespective of its odor

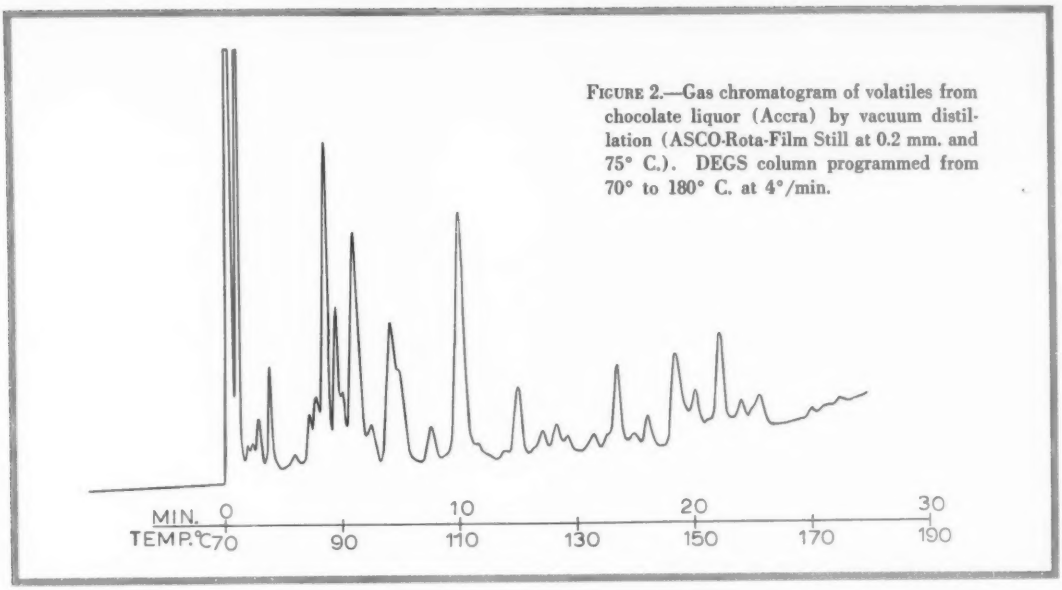

FIGURE 2.—Gas chromatogram of volatiles from chocolate liquor (Accra) by vacuum distillation (ASCO-Rota-Film Still at 0.2 mm. and 75° C.). DEGS column programmed from 70° to 180° C. at 4°/min.

potency. Thus, in figure 2, the big peaks may be irrelevant; important components from an aroma standpoint may have produced only a small peak or none at all. When and if a detector is found that responds linearly with odor intensity, we will probably have answered a major part of the question as to how odor is perceived by the human; or more particularly what property of volatile substances determines odor intensity.

Another new technique useful in the flavor field is TLC, which permits separation of very small amounts of complex mixtures on glass plates coated with such substances as silica gel. This procedure, applied to the various classes of carbonyl compounds in chocolate (liquor), again emphasizes the complexity of the flavor. Analysis has confirmed the presence of more than 30 carbonyl compounds.[2] With at least a half dozen other major classes of compounds involved, there is no great risk in estimating that volatile components of chocolate number at least in the hundreds.

[2] For some of the methodology used in this research, the authors acknowledge assistance from the following sources: (*a*) Badings, H. T., and Wassink, J. G., *Separation and Identification of Aliphatic Aldehydes and Ketones by Thin Layer Chromatography of the 2,4-Dinitrophenylhydrazones*. Neth. Milk and Dairy, J. 17: 132, 1963, and (*b*) Schwartz, D. P., Haller, H. S., and Keeney, M., *Direct Quantitative Isolation of Monocarbonyl Compounds from Fats and Oils*, Anal. Chem., 35: 2191, 1963.

APPLICATIONS

THE newer instruments and techniques are being applied unrelentingly to characterize the natural flavors and to enable synthesis of them completely in the laboratory. There is sufficient evidence of progress to suggest that satisfactory results are simply a matter of time, and that the synthetics may ultimately be better than the real thing in several respects. Components that contribute little or nothing, especially those that deteriorate to undesirable components, can be omitted. Important unstable or reactive components may be stabilized. And any substances of possible toxicity can be eliminated.

Furthermore, these instruments and techniques may be of considerable assistance to that most vexing aspect of the problem—human judgment. Three people might give three different descriptions of flavor for a food item. Yet the same three people with the same sample may completely reverse themselves (individually, collectively, or both) the next day. Even with a larger number of people, the resulting flavor statistics are not always sufficiently clear cut and reliable to guide production, product development, and marketing decisions. Here is a significant point: While there will never be an adequate substitute for the human flavor ob-

server with his capacity for value judgment, the machine can probably take much of the cost and uncertainty out of the situation in certain instances. At the same time it may provide information which is much less vague. As an example, consider the GC data of figure 3—chromatograms for headspace volatiles of several different cocoa beans, unroasted, roasted (nibs) and ground (liquor). Data for five processors are shown except for the Accra results which include only four. A bean of a particular variety is not necessarily from the same source for any of the processors. The three major peaks evident in most of the chromatograms are tentatively identified from left to right as 2-methypropanal, acetic acid, and 3 methybutanal. Presumably, these components are positively correlated with chocolate aroma. Without belaboring the data of the figure, several fairly useful observations can be made:

(*a*) Roasting produces volatiles.

(*b*) A substantial part of chocolate volatiles produced by roasting is lost during grinding.

(*c*) The roasting and grinding procedures of a given processor seem to achieve a rather uniform effect on the headspace volatiles irrespective of the variety of bean.

(*d*) Insofar as headspace volatiles are concerned, the roasting and grinding procedures appear to be very important in that they influence both the qualitative and quantitative aspects of the pattern.

(*e*) GC analysis of headspace gases can be a simple and reproducible means of analyzing part of the aroma of chocolate materials.

Useful information can also be derived from TLC, such as comparing the saturated aldehydes as their dinitrophenylhydrazones from a number of chocolate liquors.

Even the limited data now at hand make clear that the modern instruments and methods have potential to do much to standardize and maximize flavor quality by supplementing human judgment. The present obstacle is the need to develop and apply the methods and instruments to the problems in particular areas.

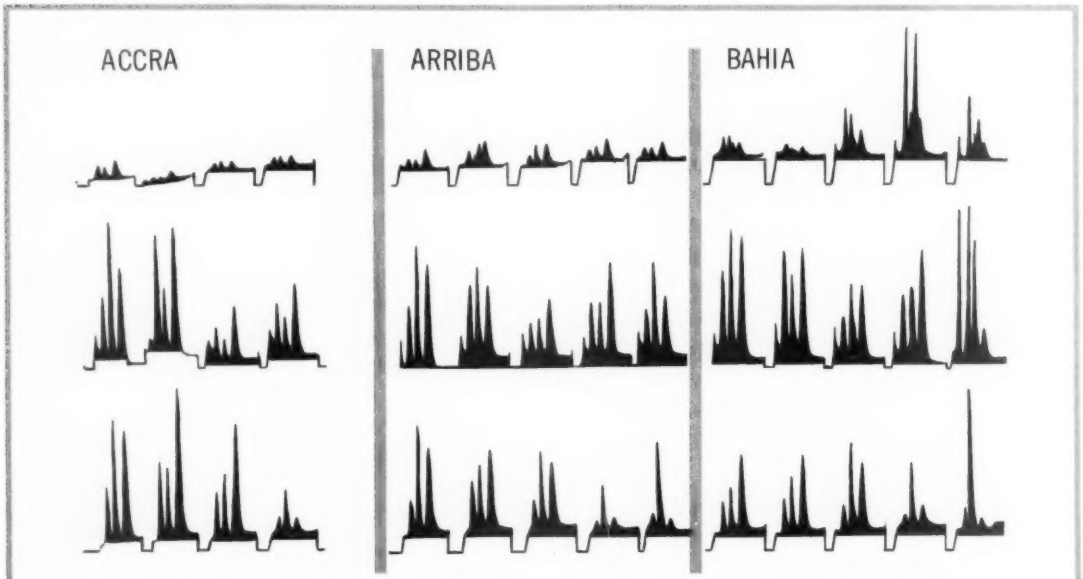

FIGURE 3.—Headspace gas analysis by gas chromatography of unroasted beans (upper), nibs (middle), and liquor (lower) for three varieties of beans as processed by five manufacturers (less No. 5 for Accra). Sample size, 5 ml. for nibs, 10 ml. for unroasted beans and liquors. Gas chromatographic analysis on DEGA column at 45°. Preparation of materials for sampling as given in: *Studies on the Volatile Components of Different Varieties of Cocoa Beans,* Bailey, S. D., Mitchell, D. G., Bazinet, M. L., and Weur man, C., J. Food Sci., 27: 165. 1962.

Soil-Applied Urea Herbicides in Control of Unwanted Woody Plants

ROBERT D. SHIPMAN

IN 1957, a new approach and challenge to the science of woody plant control was created with the manufacture and commercial registration of a substituted urea herbicide in dry, pelleted form. Although other formulations of this class of chemicals have been registered and used for brush control as granular and wettable powders prior to and after 1957, fenuron (3-phenyl-1,1-dimethylurea) was the first nonliquid herbicide formulated as a pellet. Fenuron-TCA (3-phenyl-1,1-dimethylurea trichloroacetate), a close relative of fenuron and possessing similar properties, was introduced on the market in 1960.

Because of their very low volatility, low-dosage requirements, and obvious ease of soil application, pelleted substituted ureas have been used in a wide variety of land management and woody plant control programs since their introduction. In noncultivated areas such as utility, pipeline, and railroad rights-of-way where a high degree of complete vegetative control is desirable, these materials are extremely effective. Despite the apparent variability in performance of soil-applied herbicides, they are now being used for specific purposes along fence rows and for pasture renovation, range improvement, and watershed and wildlife habitat improvement. Recently, the substituted ureas—fenuron and combinations of fenuron and TCA—have been accepted as valuable new tools for forest site conversion, site preparation, and in the selective control of undesirable woody plants.

Despite their growing usefulness, much remains to be learned about the role of pelleted herbicides in the control of unwanted woody plants. Therefore, it seems appropriate to take a close look at how they work, their relative merits, and the research problems needing most attention.

HOW SUBSTITUTED UREAS WORK

Behavior in the Soil

THE term "soil sterilant," when used in referring to the substituted ureas and other closely related

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compounds, can be grossly misinterpreted unless qualified as to the varied effects it will produce. Ordinarily, we think of soil sterilants as chemicals that make the soil totally unfit for plant growth, such as arsenic, sodium chlorate, and borate. However, the degree of soil sterility and plant selectivity of a sterilant depends primarily on its rate of application, chemical formulation, solubility, soil-adsorbing properties, and the plant species and seasonal climatic conditions under which it is used. When a substituted urea herbicide is scattered or precisely applied to the soil surface, its effectiveness as a controller of plant growth immediately is governed by the many soil obstacles it must overcome before entering the plant root system. Chief among these obstacles are photochemical decomposition, adsorption on soil particles, biological degradation, and volatilization—factors which will regulate and determine the amount and speed with which a soil-applied herbicide ultimately reaches the plant leaf. In a restricted sense, the dry formulated herbicides may be classed as "weather dependent," since rainfall and soil moisture are so closely associated with herbicide action.

The granular and pelleted substituted ureas effectively tested for control of weeds in agronomic crops and woody plant species are neburon, diuron, monuron, and fenuron. All four of these ureas kill plants by entering the root system and, after movement to the leaf or site of action, by inhibiting the Hill reaction—that is, the evolution of oxygen during photosynthesis. Since the degree of leaching of these compounds varies according to the amount of moisture in the soil, it is important to have some definite information on their solubility in water. The decreasing order of the relative solubilities of the four substituted ureas follows:

Fenuron and, to a limited extent, monuron have received most attention in the control of woody shrubs and trees because they are readily leached into soiis by rainfall. These two ureas, in addition to having the highest water solubility, also possess the lowest soil colloidal adsorption properties—characteristics that give them a preferred position in the control of woody plants in nonsensitive crops.

Most of the fundamental research on the behavior, downward movement, and residue accumulation of substituted ureas in the soil has been conducted with monuron—a urea formulation with a water solubility about 15 times less than its near relative, fenuron. Most investigators have concluded that conditions which favor microbiological activity (moisture, pH, organic matter, fertility, and temperature) also favor the disappearance of ureas from soils.

Reid (*10*)[1] investigated the response of soil microorganisms on monuron, diuron, and neburon. In a 12-year study, he found that not one of these compounds was immune to microbial attack, although some disappeared from the soil much more rapidly than others. Soil organic matter content in these studies varied from 2 to 20 percent. The speed of degradation of the urea herbicides by *Pseudomonas* was increased in the presence of increasing amounts of nitrate nitrogen, because these organisms often use oxygen from the nitrate when atmospheric oxygen is limited. At pH levels below 6.5, the rate of decomposition slowed noticeably. Also, Reid showed that the rate of degradation was affected by the moisture level, thus indirectly affecting the speed of bacterial activity as related to the oxygen supply. These studies revealed that

[1] Italic numbers in parentheses refer to Literature Cited, p. 27.

Common name	*Chemical name*	*Solubility in water (25° C.)*
		p.p.m.
Fenuron	3-phenyl-1,1-dimethylurea	3850
Monuron	3-(p-chlorohpenyl)-1,1dimethylurea	230
Diuron	3-(3,4-dichlorophenyl)-1,1-dimethylurea	42
Neburon	1-n-butyl-3-(3,4-dichlorophenyl)-1-methylurea	5

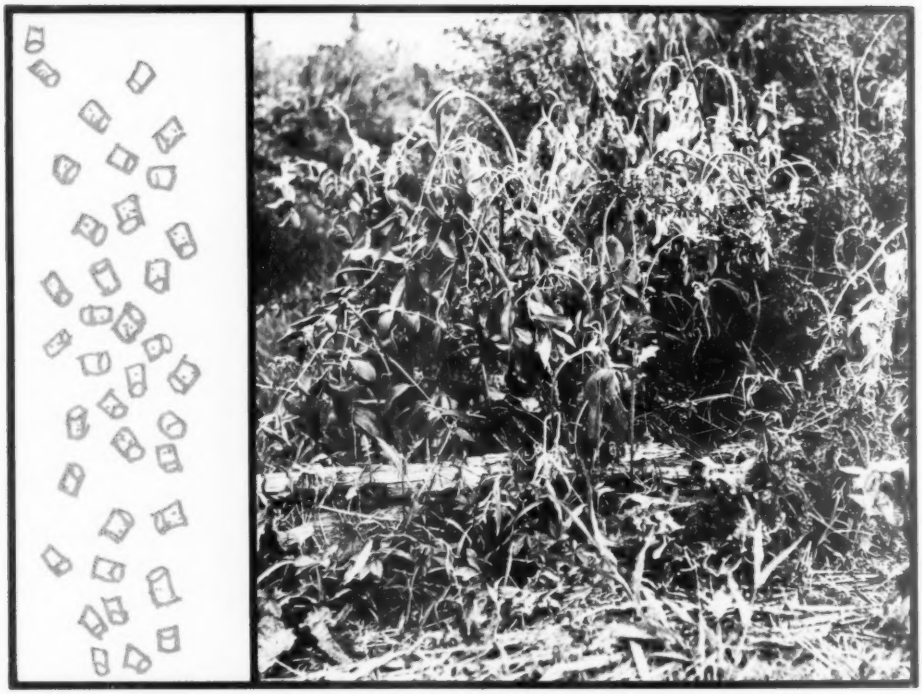
temperatures favorable to most rapid destruction of the urea herbicides ranged from 70° to 85° F.

In studying the fate of substituted urea herbicides in agricultural soils, Hill et al. (*7*) evaluated the importance of volatilization, leaching, chemical decomposition, and biological degradation in a variety of soil types. They concluded that volatilization is unlikely to account for the disappearance of more than a small fraction of these compounds under most field conditions. In the same study, using lysimeters, they showed that some leaching occurred with high volumes of water (representative of high rainfall) at a 10-pound-per-acre herbicide rate. At rates of 1 to 2 pounds per acre, the removal of ureas from the soil by percolating water was not regarded as a major factor. When little rainfall occurs after application, and the chemical remains on bare soil, photodecomposition can occur; under drought conditions, especially in areas of the West, photodecomposition may become a positive factor in disappearance of ureas from soil. The investigators indicated that under field conditions microbiological decomposition was the most important factor in soil losses of these herbicides. Additional studies by Hill and McGahen (*6*) have shown that soil bacteria of the genera *Pseudomonas, Xanthomonas, Sarcina,* and *Bacillus* and such fungi as *Penicillium* and *Aspergillus* can utilize 3-(p-chlorophenyl)-1,1-dimethylurea as a sole source of carbon by oxidizing this compound.

Sheets and Crafts (*11*) have studied the initial and residual toxicities of four substituted ureas—monuron, diuron, fenuron and DMU (3-(3,4-dichlorophenyl)-1-methylurea)—on a clay-loam soil type under autoclaved and nonautoclaved soil, and upon continuously wet soil as opposed to soil which was dry every other month. They concluded that the toxicity of all four compounds was lost more rapidly in nonautoclaved soil and that toxicity disappeared more rapidly in continuously moist soil. Of the four herbicides, fenuron was inactivated most rapidly in nonautoclaved soil. Their results suggest that micro-organisms are important in the breakdown of these herbicides, although the capacity of soils to adsorb the urea herbicides varies greatly.

In a series of experiments, Upchurch and Pierce (*14*) investigated the effects of amount, intensity, and frequency of simulated rainfall upon the leaching of monuron from a Lakeland sandy soil. They applied monuron at 40 pounds per acre to the surface of soil columns and by varying the intensity and frequency of simulated rainfall were able to separate the leaching process into two steps: (*a*) the entrance of the herbicide into solution and (*b*) adsorption of monuron on the soil from the percolating solution. The rainfall intensity factor apparently affects the adsorption step but has little effect upon entrance of the herbicide into solution. These investigators showed that lower intensity applications of rainfall resulted in a greater removal of monuron from the upper soil horizons than did less-frequent applications. The interpretation of these results was that less-frequent applications allowed more moisture to evaporate from the soil surface; hence, less moisture was available to percolate through the soil. Intensities of rainfall varying from one-sixteenth acre-inch per application to 4 inches had a negligible influence on the amount of monuron removed from the 0–2-inch soil horizon. Results from further elaboration of these studies indicated that soil organic matter had a pronounced effect on the leaching of monuron. Soil temperatures from 41° to 113° F. apparently had little effect on the amount of monuron leached from the 0–2-inch layer.

Some research evidence is available which suggests that soil and water factors are closely related to the uptake of fenuron by oak root systems. Shipman (*12*) in 1961, recorded the monthly rainfall pattern from January through October on physiologically dry, sandy soils of the Carolina sandhills. Over 65 percent of the total annual rainfall of 42 inches fell during the 5-month period—February through June—defined as the "effective period of plant kill." Pelleted fenuron had been applied in March, and a close examination of the recorded precipitation showed that 4.07 and 5.95 inches of rain had fallen 3 weeks prior to and 3 weeks after application. Continued investigations along these lines may provide sufficient quantitative data for using the amount and frequency of rainfall to predict or anticipate a given level of plant kill under relatively uniform soil types. In the test described above, it is worth pointing out that the rainfall occurred on extremely leached, acidic, deep sandy soils deficient in organic matter. Under this set of soil and precipitation conditions, turkey oak (*Quercus laevis*) was nearly 100 percent controlled and free of basal sprouting.



In the South Carolina Piedmont, Shipman (*13*) applied fenuron pellets at the rate of 20 pounds per acre on heavy clay soils and found no appreciable chemical residue 5 months after treatment. Oats and loblolly pine seeds were sown in pots containing soil obtained at 4- and 8-inch depths from pellet-treated areas and from untreated areas as controls. Both indicator plants developed satisfactorily, and growth was essentially the same on soils obtained from treated and control plots. Results of these trials suggest that other environmental factors such as microbial decomposition, pH, and leaching may compensate or override the strict differences between soil types. Similar bioassay investigations have recently been completed by Eichert (*4*) to determine the residual chemical activity of fenuron-treated soils following a 5- and 10-pound active application on sandy loam and shaly silt loam soils of central Pennsylvania. The residual chemical activity for the highest rate applied was less than 2 pounds of active fenuron per acre to an 8-inch soil depth 5 months after treatment. It was concluded that phytotoxic concentrations of fenuron disappear rapidly under the soil and climatic conditions of this area, and are of no practical toxic significance. The above results obtained under field conditions have been substantiated by other workers. On a moist, loam agricultural soil, Klingman (*8*) has shown that fenuron applied at the rate of 4 to 40 pounds per acre will persist in the soil for 3 to 12 months after treatment.

Results from virtually all basic investigations have indicated a close relationship between the affinity of soil organic matter and the adsorption properties of the asymmetrical substituted ureas, depending upon their solubilities and phytotoxic properties. Leaching of these materials is generally restricted to the top 2–3-inch soil horizons. Microbial decomposition is rapid enough that any toxic residues from the chemical remain far below the tolerance levels required for control of brush or woody plants.

Behavior in the Plant

In 1937, Hill (*5*) discovered that oxygen in cells of higher plants is evolved by isolated chloroplasts

upon exposure to light—even though the chloroplasts have lost their ability to reduce carbon dioxide. It is this principle—a photochemically induced decomposition of water into protons [H+] and hydroxyl ions [OH−]—by which substituted ureas control growth and kill plants by inhibiting the oxygen byproduct. The interference of the photosynthetic process by these herbicides may, however, involve other complex physiological reactions besides the split of water. It should be recognized that research on the interference against the Hill reaction has been largely conducted with isolated chloroplasts under laboratory circumstances, and that reactions with special chlorophyll molecules outside the chloroplast have been postulated.

To understand how substituted ureas exert their influence upon woody plant growth, one must identify the routes of movement and site or sites through which growth is altered. For example, it has been fairly well established that the substituted urea molecules travel principally in the transpiration stream of the xylem, known as the apoplast, or the continuous, nonliving cell wall phase surrounding the symplast (living phase). Muzik et al. (*9*) showed that monuron definitely enters plants through the roots, but it is not readily translocated downward from the plant apex to the base or from leaf to stem. Crafts (*3*) using C^{14} labeled herbicides, has verified these findings by showing that the urea compounds diffuse into the transpiration water, moving in a direction from the main transpiration stream in the fine veins toward the periphery of the leaf. Although visible responses differ with the plant species affected, there is initially a marginal dieback and general loss of turgidity, followed by chlorosis and eventual death.

The site of toxic action of substituted ureas in plants is most closely associated with the chloroplast—the structure capable of trapping light energy. The chloroplast contains the essential pigment, chlorophyll, which is located in the grana or rodlike structures organized into alternating layers of chlorophyll and protein. It has long been accepted that the chlorophyll molecule, with the aid of light, could split carbon from carbon dioxide, freeing the O_2, with the addition of this carbon to water to form the familiar carbohydrate compounds of the type $(CH_2O)n$. Arnon (*1, 2*) and his associates, however, set the stage for a new hypothesis about the role of light in photosynthesis, by showing that most cells, including animal cells, were able to "fix" CO_2 in the dark, and in the *absence* of chlorophyll. Equally as important, these investigators demonstrated that some cells do not give off O_2 under photosynthetic conditions; but instead give off H_2, NH_3, or other substances.

Further work by Arnon and his coworkers showed that chloroplasts could convert light energy into the chemical energy of ATP (adenosine triphosphate) *without* oxygen. Thus, water is not only split to yield oxygen, but the hydrogen proton is also utilized in the simultaneous formation of three end products—reduced triphosphopyridene ($TPNH_2$), adenosine triphosphate (ATP) and oxygen. The term "ferredoxin" has recently been ascribed to those iron-containing proteins which play a key role in the energy transfer mechanisms of photosynthesis.

To disrupt the photochemical process, the most potent inhibiting herbicide would be capable of blocking the oxidation of water to molecular oxygen, or by rupturing the hydrogen bonds that maintain the protein structure. All four of the substituted methyl ureas—fenuron, monuron, diuron, and neburon—possess the NH group in common, capable of forming hydrogen bonds.

Van Overbeek (*15*) has envisioned the manner in which a plant may react to poisoning with the substituted urea compounds. Suppose, now, a tree is poisoned with fenuron pellets applied to the soil at the base of a tree. In the light, electrons flying out of the chlorophyll are trapped by electron acceptors. These acceptors may well include molecular oxygen. However, the holes that are left behind are not readily refilled as the supply of electrons from OH− (a split water molecule) is blocked by fenuron. As light intensity increases more electrons are shot out, leaving more holes in the chlorophyll unfilled. Eventually the chlorophyll molecules are so depleted that they are no longer active. Chemically speaking, the chlorophyll is oxidized. Anyone who has held a test tube containing chlorophyll solution in strong light knows that it becomes oxidized and bleached and is no longer capable of aiding in the production of sugar. In a tree or plant this bleaching is prevented because the chlorophyll molecule is cushioned in protein and situated in a structure which allows a constant backflow of electrons from water. When this backflow of electrons is blocked by fenuron, chlorophyll is subject to oxidation and bleaching. This explains the chlorosis and collapse

of the young leaves which are observed as symptoms of fenuron toxicity.

ADVANTAGES OF SOIL-APPLIED UREAS

NOT all of the problems associated with the use of pelleted, soil-applied urea herbicides have been solved, nor do they offer any panacea for control of unwanted vegetation. Nonetheless, they have many technical, economic, and biological characteristics that appear promising for the control of woody plants and brush.

The following potential advantages of pelleted, substituted ureas have been supported by research findings and actual use:

1. They are easily and rapidly applied by hand or aircraft to the soil surface.

2. When used according to the manufacturers' recommendations, they are relatively nonhazardous to man, animals, and wildlife.

3. They have a negligible soil and plant residual factor and are nonvolatile.

4. When applied at recommended rates, they appear to have a high degree of plant selectivity—both within and between woody coniferous and broadleaf plants.

5. They can be applied as broadcast, grid, band, or spot treatments that can be tailored to the approximate level of kill desired.

6. They require practically no initial capital investment in application equipment; there are no significant depreciation or maintenance charges.

7. They can be used for control of undesirable woody plants in many areas considered too expensive and inaccessible to control with heavy equipment.

8. They can be applied with a minimum of supervision and with low labor costs in contrast to other herbicides.

9. They require no elaborate mixing, carriers, or dosage computations.

10. Soil-applied, substituted urea herbicides enter the plant through root systems directly, moving exclusively in the nonliving xylem to the leaves or site of action. Thus, translocation and mobility are continuous, without local tissue disruption.

11. Activity, or killing power, is not confined exclusively to such variables as plant size, stage of vegetative development or rigid dosage requirements. As long as chlorophyll is being manufactured and the soil solution of active herbicides is in contact with part or all of the root system of susceptible woody plants, the killing action will occur.

THE RESEARCH PROBLEMS

ALTHOUGH we know several of the physiological mechanisms involved in controlling woody plants with pelleted or dry substituted urea compounds, we still need more quantitative information about the dynamic interactions involved between the soil-adsorbed herbicide and its mode of uptake by roots. Additional studies are needed in order to interpret the usefulness of ureas for controlling a wider variety of woody plants growing on diverse soil types. The purely physical processes of leaching and diffusion of herbicides in the vapor, liquid, and solid phases in the soil system should be studied in great detail.

What are the basic mechanisms involved in the uptake of soluble pellets through partial and total root systems as related to time and concentration? Why, as shown by past studies, are planted coniferous tree seedlings relatively unharmed when substituted urea pellets are scattered near their base, while overstory hardwood trees in the same stand are affected? How is rooting depth of perennial woody plants related to their capacity for adsorption of herbicides at varying concentrations? These are some of the questions that, hopefully, further research might answer.

In the past, most of the fundamental research studies conducted on soil-applied herbicides have dealt principally with annual agronomic plants, and often in the laboratory under controlled environments. It is obvious that future research on the so-called "weather-dependent" soil-applied herbicides will be most closely linked to the soil-weather-plant complex. Soil moisture and soil properties appear to be the primary targets for intensive studies capable of revealing some of the vagaries of the dynamic soil-water system.

If we are to define and interpret the many complex soil processes associated with the degradation, adsorption, and physical decomposition of soil-applied herbicides, we cannot divorce future investigations from the effects of microbial activity and the role of organic matter on the above processes.

What is the relationship of chemical structure of the urea herbicides to their decomposition by major classes of soil organisms? Does surface leaf litter on

uncultivated sites have any significant effect on the rate of herbicide breakdown and subsequent root uptake? Along these lines, we can hypothesize as to the threshold toxic limits of the initial herbicide dosage for a given species growing on a variety of soil types. What are some of the spatial relationships involved in broadcast, grid, and spot applications of soil-applied materials? And finally, what is the relationship between size and form of soil pellet or granule and its active ingredient? Can we increase the amount of inert carrier at the expense of reduced active ingredient per pellet, and achieve as good, or better kill?

It is the writer's opinion that we have entered a new and challenging era in the control of woody plants through soil application. But we need to establish and define those parameters most closely associated with a level of kill desired and consistent with a sensible economic investment in herbicide. The trial-and-error approach of the past must be refined to determine specific causes and effects of herbicidal action if we are to more fully understand the precise role of the soil-applied herbicides for control of woody plants.

In keeping with USDA policy, research workers are urged to exercise constant vigilance in the use of herbicides to assure the protection of human health by avoiding unnecessary exposure of crops, livestock, fish, wildlife, and water supplies.

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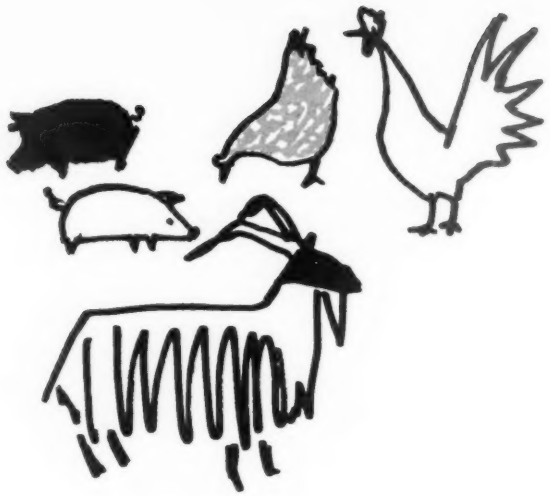

G. L. WAXLER

SPECIFIC-PATHOGEN-FREE AND GERMFREE ANIMALS IN RESEARCH

ONE of the areas of research which has received an increasing amount of attention over the past two or three decades is the rearing of animals under conditions in which living micro-organisms are excluded from the environment. The first attempts to rear germfree chickens and laboratory animals, made around the turn of the century, were often unsuccessful. Despite these early frustrations, however, efforts to achieve strict control of the microbial environment have continued, and equipment and techniques have now developed to the point that a significant number of animals can be reared under germfree conditions. Much of the attention has been directed toward chickens and laboratory animals such as rats, mice, guinea pigs, and rabbits, although within the past 10 years larger animals, including dogs, sheep, goats, and swine, have been reared under germfree conditions. As techniques become more refined and equipment becomes more readily available for handling germfree animals of the food-producing species, it logically follows that the demand for the use of these animals in research will increase. There are many research problems in areas such as nutrition, infectious diseases, and the study of environmental factors in which use of the germfree animal should be of value.

TERMINOLOGY

NUMEROUS terms have been used to denote animals kept in an environment controlled with respect to its microbial flora. *Specific-pathogen-free* (SPF) is used to denote animals which are free of one or more specific organisms causing disease in that particular species. In poultry this term might be used to designate freedom from *Salmonella pullorum,* while in swine it has been applied to animals free of the agents causing infectious atrophic rhinitis and virus pneumonia of pigs. For this term to be meaningful, one must therefore specify

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the infectious agent or agents from which the animals are known to be free. Some workers have called these animals *disease free,* but this term lacks specificity and is now rarely used. The fallacy of this terminology is shown by the fact that animals may be affected with a variety of nutritional and infectious diseases and still qualify as SPF animals so long as the diseases specifically designated are not present. Obviously, such animals are not *disease free.*

Germfree refers to the condition of an animal kept in an environment free of other demonstrable forms of life. Under the conditions of most research, the greatest amount of attention is given to the absence of bacteria, but in reality this term means that the animal is also free of protozoa, fungi, viruses, helminths, etc. The term *axenic* (meaning "free from strangers") is, for all practical purposes, the equivalent of *germ free.*

The word *gnotobiotic* (meaning "known life") is more flexible than *germ free* or *axenic* in that it denotes animals reared in the absence of other living organisms *or* in the presence of specifically known associates. A *gnotobiotic* animal may, therefore, be *germ free,* or it may have one or more species of micro-organisms in its environment. The term *gnotobiotics* refers to this field of investigation, while the animals kept under these conditions are known as *gnotobiotes.*

TECHNIQUES AND EQUIPMENT

THERE are two possible methods of obtaining germ-free animals. One consists of "decontaminating" a conventionally reared animal in such a way that the external and internal microflora are completely removed. Numerous attempts have been made to accomplish this by the use of a variety of antimicrobial agents, but most attempts have been only partially successful.

The second method of obtaining germ-free animals takes advantage of the fact that the developing fetus is, with few exceptions, free of demonstrable micro-organisms. The technique for obtaining germ-free animals consists essentially, then, of aseptically transferring the fully developed fetus from the uterus of the dam (or the egg) into a sterile environment. Under practical conditions this is accomplished in mammals by performing a hysterotomy or hysterectomy on the dam near the end of the gestation period or, in birds, by sterilizing the external surface of fertile eggs and allowing them to hatch within a sterile isolator.

The techniques and equipment for germ-free research have evolved gradually since the first part of this century, and the early efforts in this work have been reviewed by Gordon (*1*) and Luckey (*4*)[1]. Much of the early work in the development of germ-free research in the United States was done by workers at the University of Notre Dame. Here, Reyniers (*9*) and his group designed isolators in the form of metal cylinders which were heavy enough to be sterilized with steam under pressure, each isolator simply acting as its own autoclave. Air for the units was sterilized by being passed through filters containing glass fibers, and animals were handled through attached shoulder-length rubber gloves. A surgical isolator was especially designed with a plastic window in the floor so that the abdomen of a pregnant female could be placed against this plastic. An incision was made through both the plastic and the abdominal wall, and the fetuses were then brought into the sterile environment of the isolator. Fertilized eggs were passed in through a germicidal trap.

Various modifications of the metal isolator have been made in this country and elsewhere. Swedish workers have used a unit which has thin metal walls and is sterilized inside an autoclave. In Japan a heavy metal isolator with an elaborate remote control system has been designed.

Numerous isolators made of rigid plastic have also been used in rearing germ-free laboratory animals and chickens. The use of larger germ-free animals was given its greatest impetus by the development of a flexible-film plastic isolator by Trexler (*12*) and his associates. This isolator, usually made of transparent vinyl film, can be built in practically any size and shape to fit the needs of the research being conducted. It is fitted with air filters, rubber gloves, supply locks, etc., to allow for the handling, within the isolator, of the animals and the food and supplies necessary for their maintenance. The isolator is sterilized by the use of an aerosol of peracetic acid. In addition to the advantage of the greater flexibility of design possible with plastic isolators, they are also considerably less expensive than the metal type.

[1] Italic numbers in parentheses refer to Literature Cited, p. 35.

In using plastic equipment to obtain large germ-free animals, the pregnant female is anesthetized, and the uterus is removed surgically and passed into the isolator through an antiseptic lock. The young are then removed from the uterus within the isolator. An alternative procedure is to secure the bottom of an isolator to the abdomen of the pregnant female and perform a hysterotomy by incising through the plastic and the abdominal and uterine walls. Germ-free pigs, (*3*), (*5*), (*13*), (*14*), goats, and lambs (*11*) have been obtained by several workers in this manner.

DIETS

IN providing diets for germ-free animals two principal problems have been encountered. The first of these is the question of how the nutritive requirements of the germ-free animal compare with those of a conventional animal. Although much is known of the requirements of the host-flora complex as found in the animal raised under the usual conditions, little is known of the quantitative requirements of the host per se. If there are differences in requirements, it seems reasonable to assume that the differences would be apparent in the requirements of nutritional factors normally provided by the bacterial flora. This has been demonstrated in the case of vitamin K, in which a deficiency was produced by feeding germ-free rats a purified diet extracted with petroleum ether. When either of two strains of bacteria, isolated from conventional rats, was used as a monocontaminant, the germ-free animals overcame the vitamin K deficiency in 24 to 48 hours. Investigations into other nutrients such as biotin and folic acid have been made, but the results are not as clear as with vitamin K.

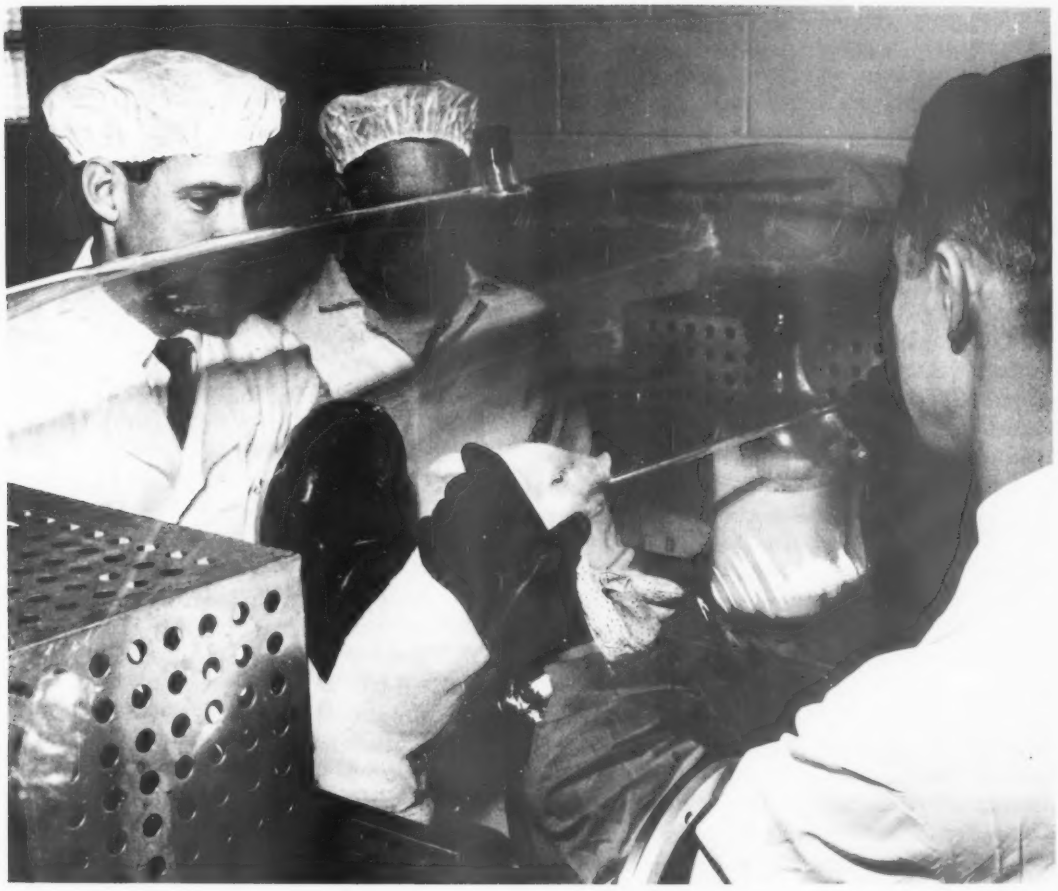
The second problem in providing diets for germ-free animals relates to sterilization of the diet. Steam under pressure has been most widely used for sterilization. Although this method produces certain changes in the physical properties of the diet such as "browning" of solid diets or partial coagulation of liquid diets based on cow's milk, the more significant changes are in the nutritive values. The vitamins are the most susceptible to breakdown by heat in steam sterilization. Studies have shown that 80 to 90 percent of the dietary thiamine may be lost at the usual sterilization temperature of 123° C. for 25 minutes. Losses of other vitamins are not more than 40 to 50 percent. Cathode rays may be used for sterilizing diets and apparently they cause less destruction of nutrients. Ethylene oxide has been used for "cold sterilization" of diets but it destroys some vitamins and amino acids. Many liquids, such as vitamin solutions, may be sterilized by passing them through a bacterial filter, thus eliminating the nutrient destruction encountered in other methods.

One of the problems in working with larger animals under germ-free conditions is that of providing the quantity of diet necessary. This has been partially overcome in working with swine by the availability of a commercially prepared, presterilized liquid ration for young pigs (*14*).

CHARACTERISTICS OF GERM-FREE ANIMALS

IN general the growth rates of germ-free laboratory animals and chickens have been about the same as or somewhat less than those of conventional animals fed the same sterilized diet. These growth rates are less than for conventional animals fed an unsterilized diet and are probably due to the inadequacy of sterilized diets. Only limited studies have been done on large animals but results indicate that germ-free pigs and ruminants grow more slowly than animals nursed by their dams.

Morphologically, the germ-free animal is similar in most respects to the conventional animal. The greatest differences are noted in the tissues normally in contact with micro-organisms as, for example, the intestinal tract. Studies have shown that the small intestine in germ-free animals is shorter, the wall is somewhat thinner, and it is lighter in weight than in the conventional animal. This is at least partially due to the fact that there is less connective tissue and fewer lymphocytes, plasma cells, and other cells in the intestinal wall. The cecum of germ-free rats, mice, guinea pigs, and rabbits is consistently enlarged in the germ-free state to several times normal size. This change is apparently due to decreased muscle tone, and when a normal flora is established in formerly germ-free animals, the cecum soon reduces in size. The contents of the cecum are rather fluid, the feces are softer and less well formed than in conventionally reared animals. The ceca of germ-free chickens are not enlarged.



The lymphatic tissues near the "external environment" as, for example, the nodes draining the oral cavity and the lymph nodules within the intestinal tract, are smaller in germ-free animals, but the amount of lymphatic tissue in other areas is normal. Microscopically there is a lesser lymphocytic concentration in the nodes of germ-free animals and plasma cells and secondary nodules are less numerous; in other words, the lymphatic tissue does not appear as active in the germ-free animal. The bursa of *Fabricius* is essentially the same in size and histological features in germ-free and conventional chickens. This condition has led to the conclusion that the bursa of *Fabricius* must differ in development and function from other lymphoid nodules. Similarly, the thymus of germ-free birds does not differ from that of conventional birds. In guinea pigs and rats, however, the thymus is relatively small.

Fewer circulating leukocytes have been reported in germ-free animals, and a lesser concentration of γ-globulin is found.

Morphologic comparisons between germ-free and conventional animals of the larger species have not been as extensive as in laboratory animals. No evidence of enlargement of the cecum has been reported but this may be due to the fact that germ-free swine and ruminants have been kept for relatively short periods. Changes in the lymphatic tissues in germ-free swine similar to those reported for other species have been noted.

Germ-free rats and mice have reproduced

through several generations, and reproduction has been reported in germ-free chickens. Considerable difficulty has been encountered with guinea pigs and rabbits, although limited reproduction has been achieved. The enlarged cecum is thought to be one of the factors interfering with reproduction in these two species, although the exact mechanism is not clear.

USE OF SPECIFIC-PATHOGEN-FREE AND GERM-FREE ANIMALS

SPECIFIC-pathogen-tree animals have been used primarily to bypass some of the of the common diseases of a species transmitted from one individual to another. In this group can be listed murine pneumonia in the rat and atrophic rhinitis and virus pneumonia of swine. By using surgical procedures to obtain the young, it is possible to start a new colony, herd, or flock with animals that have not been exposed to pathogenic organisms carried by their dams. Once the first generation, artificially reared animals have reached maturity, a normal breeding program can be carried out in subsequent generations. It then becomes necessary to obtain other animals by surgical means only to introduce new bloodlines into the SPF group.

Much publicity has been given to the SPF swine program (*18*) since its beginning in the early 1950's. This program was designed primarily to control atrophic rhinitis and virus pneumonia—two costly diseases of swine not successfully controlled by any other means. These conditions are apparently spread from the dam directly to the pig at a time when the young animal is extremely susceptible to infection. Numerous laboratories were established throughout the swine-raising areas of the country for maintaining first-generation animals until they were old enough to be placed back on "clean" farms from which all swine had been removed several weeks or months previously. These pigs then formed the nucleus of a breeding herd which could later be used to establish secondary herds of SPF animals.

In areas where this program has been successful, two characteristics are evident. First, it has been successful in controlling the two diseases in question. Second, there have been other benefits derived as byproducts of the SPF program. Sanitation and isolation have been continually emphasized to producers taking part in this program, since an extreme amount of care must be practiced to prevent introduction of infectious agents into the SPF herd. With an increasing awareness by farmers of disease and of measures to control disease has come added interest in other aspects of good management. A certain amount of pride in raising animals different from the "run-of-the-mill" swine herd has caused farmers to pay more attention to ration formulation, breeding records, and performance levels. The overall results, therefore, have been more than could be expected simply from the control of these two diseases. But further observations are needed to clearly separate the value derived as a result of disease control from that coming from improved management practices. The program at present is strongest in the States where SPF certification programs have been established not only to keep an accurate check on freedom from disease, but also to control the quality of the animals produced—an aspect of the program too often neglected in some of the early efforts.

Germ-free laboratory animals and chickens have been used for a wide variety of research purposes, only a few examples of which can be given here.

Studies with germ-free rats have demonstrated the importance of bacteria in producing dental caries (*6*). A specific diet, known to be cariogenic when fed to conventional rats, lacked this effect when fed to germ-free rats. The addition of a pure culture of *Streptococcus faecalis* to the environment of the previously germ-free rats, however, resulted in the production of severe caries when this diet was fed.

The germ-free chicken has been of value in studies of the mechanism of growth stimulation by antibiotics. It has now been well established that this growth stimulation comes about as a result of the effect of the antibiotic on the intestinal flora and a subsequent reduction in the numbers of some of the organisms tending to depress growth. As an example, when germ-free chickens were monocontaminated with *Clostridium welchii,* their growth rates were reduced. The addition of antibiotics to the ration resulted in growth rates comparable to those in germ-free birds.

Germ-free rats have been used to study the pathogenesis of hemorrhagic shock (*19*). It has been suggested that the progressive deterioration, collapse of the peripheral circulation, and fatal shock following various forms of stress may be caused

largely by bacteria and their products. In an experiment designed to investigate this possibility, germ-free and conventional rats were subjected to various degrees of hemorrhagic hypotension followed by transfusions. Results were essentially the same in both groups of animals; irreversible shock and death were the final outcome. This would indicate that the contribution of bacterial contamination to the irreversible trend would be, at most, secondary.

An example of the use of germ-free animals in the study of nutrition is that of research on vitamin K deficiency in the rat (*2*). When the germ-free rats were fed a diet containing all the known vitamins except vitamin K, they developed signs of severe hypoprothrombinemia, and hemorrhages were seen in various tissues of the body. This disturbance of the blood-clotting mechanism was alleviated by administering vitamin K or by transferring the rats from the germ-free isolators to contaminated surroundings, thus indicating the importance of the bacterial synthesis of this vitamin in the intestinal tract of the conventional animal.

Germ-free mice have been used extensively in the study of cancer. Certain chemicals such as 3-methylcholanthrene and related compounds have the ability to produce tumors in conventional animals when these substances are administered by various routes. Some of these tumors may then be transplanted serially from one animal to another. Viruses have been detected in some of these transplanted tumors, and the question has arisen as to the importance of these viruses in oncogenesis. Similar neoplasms have been induced in germ-free mice by use of the same chemicals (*7*). After several passages of the tumor tissue, no viruses could be demonstrated by use of various test procedures, thus indicating that the viruses in conventional animals were merely "passengers." In another area, however, it has been shown that viruses may be of importance in the production of leukemia in germ-free animals (*8*). When germ-free mice were subjected to whole-body x-irradiation, lymphatic leukemia was produced. When cells from the enlarged thymus of affected animals were examined by electron microscopy, cytoplasmic viral inclusions were noted. It was thus concluded that the virus had been present in successive generations of the strain of mice used, and that the irradiation acted to "unmask" this preexisting virus.

The importance of bacteria in the production of a wasting disease in mice is demonstrated by the fact that the condition is easily reproduced in conventional animals by removal of the thymus at a very early age, but the same procedure in germ-free animals fails to produce the condition (*16*).

The immunologic competence of germ-free animals has been the subject of numerous investigations. Although the level of γ-globulin in the serum of germ-free animals is quite low when compared with that of conventional animals, the ability to produce antibody is still present. This effect has been demonstrated by exposing germ-free animals to bacteria normally found in the intestinal tract (*17*). The α-globulin levels of the serum began to increase about 1 week after exposure; the β- and γ-globulins increased somewhat later. As the globulins increased, serum albumin decreased so that the total serum protein remained about the same.

Various infectious diseases have been studied with the germ-free animal as the host. In the guinea pig it has been demonstrated that *Endamoeba histolytica* requires some unknown factor which is evidently formed by bacteria in the intestinal tract. Germ-free turkeys (*10*) have been used in determining the cause of chronic respiratory disease or "air sac" infection. Typical lesions of the disease have been produced by exposing germ-free birds to *Mycoplasma gallinarum*. Signs and lesions of hog cholera identical to those recognized in conventional animals have been seen in germ-free pigs exposed to the virus alone, (*15*) thus suggesting that the effect of secondary bacterial infection in the disease under field conditions is minimal. Germ-free pigs are presently being used in studies of transmissible gastroenteritis and enteritis caused by *Escherichia coli*.

PROSPECTS FOR THE FUTURE

THERE seems little doubt that germ-free animals will be used in the investigation of an ever-widening array of research problems. To be sure, they will never completely replace the conventionally reared animal for many phases of research, but there are numerous fields which will benefit materially from the carefully controlled conditions made possible by the use of gnotobiotic animals.

A great deal of effort could be spent in reestablishing the nutritional requirements of many of our

domestic animals, since past results have reflected the needs not only of the animal but also of its ever-present microbial flora. Although it is true that, under practical conditions, the requirements of the host-parasite complex are of primary importance, a great deal of information concerning the absolute requirements of the body itself might be gained by studying the needs of the gnotobiote. By comparing these needs with those of the conventional host, the true contribution of the microbial flora to the nutritional well-being of the animal could be determined. It might thus be practical to alter the flora of the intestinal tract and thereby significantly change the nutritional needs of the host-parasite complex.

As animals of the food-producing species are raised in larger numbers under more concentrated conditions, infectious diseases have become one of the most important problems encountered. Investigation of some of these infectious diseases will certainly benefit from the use of gnotobiotic techniques. It has been a common observation that many of the infectious diseases, especially those of the gastrointestinal tract, are very difficult to reproduce under experimental conditions. As an example, *Escherichia coli,* often isolated in nearly pure culture from the tissues of pigs or calves dying of a severe enteritis, frequently fails to reproduce the typical disease when fed to other animals of the same species. Thus it seems that there are unknown variables which need to be considered in studying this disease. It may be possible that certain components of the diet alter the growth rate of the infectious agent within the intestine or that imbalances in the normal flora of the tract play a role in increasing or decreasing the ability of *Escherichia coli* to act as a pathogen. By using germ-free animals it may be possible to reduce the number of variables encountered in this work and thus more clearly define the role of this and other organisms in producing disease. Attempts should be made to simulate a normal flora within the intestinal tract by selectively contaminating a previously germ-free animal. It would then be possible to establish variations of this normal flora by leaving out one or more components, thus helping to supply information on some of the complex interrelationships existing among the wide variety of organisms found within the intestinal tract. Work of this kind would require the team approach if significant results were to be expected. The nutritionist, microbiologist, biochemist, physiologist, and pathologist would all be vitally interested in such a project.

The shipping fever complex in cattle should also be investigated in gnotobiotic animals. The relative importance of the various viral and bacterial agents could be investigated by using the germ-free techniques now presently available.

Still another disease of questionable etiology is atrophic rhinitis of swine. The various causative agents mentioned in the past have included numerous bacteria, pleuropneumonia-like organisms, protozoa, viruses, and even nutritional factors. There seems no better approach to determining the cause or causes of this disease than to introduce these agents, one at a time or in various combinations, into germ-free pigs.

One important factor in large animal gnotobiotic work is the high cost of producing and maintaining such animals as pigs and calves under conditions in which they are completely free of bacteria. This is less of a problem in laboratory animals where reproduction under germ-free conditions has become routine. Techniques and equipment may gradually evolve to the point that large-animal colonies may be established under similar conditions. It would seem more practical at the present time, however, for centers or laboratories to be established to provide germ-free animals to other investigators for research on specific problems. The number of animals required could no doubt be supplied much more economically and efficiently by a well equipped and staffed center than by each worker attempting to produce his own animals. Breeding herds with accurate breeding dates, established bloodlines, and uniform quality could be maintained by these laboratories so that gnotobiotic calves, lambs, pigs, or other animals could be made available on a schedule suited to the needs of the research worker. Such services are available to the investigator using rats and mice; there is no reason to believe that they will not become available to the worker interested in large animal research in the future.

As the cost of conducting research continues to increase, more and more attention must be given to the quality of the work being done. No longer can the investigator afford to use as subjects for his

experiments whatever animals happen to be available. He must make every effort to work with animals that are of a known quality if his research is to be of the greatest value to himself and others in the field within which he is working. In many areas of basic research the germ-free animal provides this needed quality and uniformity, and it is logical that its use will increase in the future.

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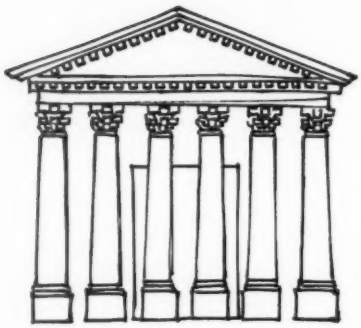


FORUM

HINDRANCES TO PROGRESSIVE RESEARCH

S. Pawluk

SOMETHING must be seriously wrong when individuals are willing to abide by the standards set forth in editorial policy while serving as reviewers but are not willing to follow these same standards as authors. This by no means is meant as criticism of the efforts of the reviewers, who in my opinion are doing superb jobs. But I believe this siutation simply reflects the frustrations authors experience when many of their ideas are excluded from publication because they do not lend themselves to verification by the included data. Such ideas are generally rejected by reviewers on the basis that they are beyond the scope of the paper. I believe that many of the ideas gained through insight during experimentation are invaluable for formulating a basis of research in related problems. Ideas that originate only during the course of experimentation should be recorded and published so that they may stimulate researchers in related fields, who may "pick up the threads and press ahead."

It is no wonder that readers are beginning to regard published material with indifference and often hardly take the time to read abstracts in their own fields. This attitude reflects the fact that many researchers feel it is no benefit to them to read papers with more than a casual glance.

Condensed from *Agricultural Institute Review* (Canada) Vol. 21, No. 1, 1966.

I am certain that I speak for many others in stating that my interest in a paper goes deeper than just a comprehension of the present conclusions. Many scientists search the literature for ideas. Whether such ideas are based on factual data is immaterial as long as they are based on some experimentl evidence or experience gained during the course of research. Whether such ideas are in complete accord or direct conflict with the thinking of fellow researchers is not important. The publishing of such information could stimulate research in a progressive manner.

Surely, one of the prime purposes of any scientific journal is to establish communication among scientists. Too often, however, our journals are used as a final burial ground for completed research projects, many of which are of little genuine interest (often not even to the author).

I propose three changes in editorial policy.

Authors should be provided with greater opportunities to discuss significant experimental observations, even if only remotely related to the immediate objectives of the research project. The main objective here would be to establish a dialogue among researchers that, among other things, may arouse interest in unexplored areas of research. This exchange in turn may lead to new projects that would not otherwise be instigated on an individual or local basis. Many of our major scientific breakthroughs were established by a step-by-step and regional approach to research originating from some "odd-ball" idea.

I always hear the argument that inclusion of additional information would greatly tax the already scarce space in our journals. Surely, this argument is not valid and may readily be resolved by using a little logic and imagination. Why not delete much of the "Methods" section? Because most procedures are not new and often already summarized, why not list the references after the analysis in question, in the "Discussion" section? (For example . . . The mechanical composition of the soil (Toogood and Peters, 1959) was found to vary . . . .) The "Methods" section would then include only those procedures not reported elsewhere in the literature.

Why not delete a few pages from the "Results" section, or even do away with it entirely? Pertinent data are generally covered adequately in the "Dis-

cussion" section. Although I realize it is essential for editors and reviewers to have access to all data, I wonder if any real purpose is served by publishing any of it. Few people have sufficient time to scrutinize data in a detailed fashion. Those who may find some special interest in such information could obtain it by directly contacting the author.

Most scientists would agree that reviewing papers is a burden for those who are fully occupied with their own research, teaching, or extension duties. Moreover, competent reviewers for highly specialized fields of research are few and far between. Thus, the task of reviewing often falls on a few shoulders.

Therefore, I recommend exploring the possibility of making better use of the many talented researchers who are now in retirement. Under present circumstances where page charges are in order, it should not be difficult to provide financial remuneration for such efforts. Benefits would be twofold: The bulk of the reviewer's responsibilities would be transferred to those who would have adequate time to do a thorough job. At the same time the plan would provide an opportunity for these very knowledgeable people to play an important role in today's research. After all, nothing can be substituted for experience. Perhaps even more important, these people have no "axes to grind".

In publications of an earlier era, it was commonplace for authors not only to expound on all aspects of research in their publications but often to dwell upon philosophical views in such fields as politics and religion. However, in more recent times acceptance of material for publication has become more restrictive—in fact to such a degree that we have swung from the ridiculous to the sublime and back to the ridiculous again. Is it not time that we established a more moderate editorial policy with greater permanency?

In conclusion, I submit that editorial policy should be altered in such a fashion that its principal aim would be the fostering of an interchange of ideas based on scientific experience—call it "intuitive thinking" if you will—as well as on factual data. Such an approach would greatly enhance the progress and quality of research, and keep it moving steadily in a positive direction.

Dr. Pawluk is a soil scientist at the University of Alberta and a former science editor of the Canadian Journal of Soil Science.

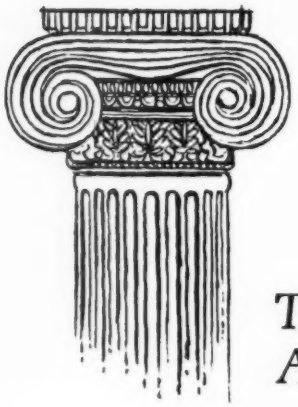
A Review of Apple Marketing Research

A REVIEW of recent literature on maintaining quality of apples from harvest to retail outlets has been published by the U.S. Department of Agriculture.

The 215-page review covers aspects of harvesting, handling, storage, and transportation of apples as they affect biological and physical qualities of the fruit. It was prepared by market researchers of USDA's Agricultural Research Service as an aid to the apple industry and to public and private organizations planning research on apple marketing.

More than 1,200 research publications are represented in the review which deals primarily with studies reported since 1945 by USDA, State agricultural experiment stations, and other organizations both in the United States and abroad. Economic phases of marketing are not included in this report; these were reviewed in a 1963 USDA publication. Literature on engineering and marketing facilities are also largely excluded, although a few references relating to costs, engineering, and marketing facilities are discussed when they concern the subject being reviewed. The largest section in the report—184 citations—deals with literature on market diseases.

Copies of "A Review of Literature on Harvesting, Handling, Storage, and Transportation of Apples," (ARS 51–4) may be obtained by writing to Horticultural Crops Research Branch, Market Quality Research Division, ARS, USDA, Beltsville, Md., 20705.



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ROBERT D. SHIPMAN ("Soil-Applied Urea Herbicides") is associate professor of silviculture at the Pennsylvania State University. He obtained his BSF and MF degrees from the University of Michigan in 1947. In 1952 he received his Ph. D. in forestry from Michigan State University. He was a research forester at the USDA Southeastern Forest Experiment Station from 1952 until 1958 when he joined the staff of Clemson College. In 1963 he joined the Pennsylvania State University staff, School of Forest Resources. Dr. Shipman conducted the first aerial applications of pelleted herbicides in the Southeast, aimed at converting low quality forest stands into fast-growing pines. He has had wide experience in forest regeneration research and the application of herbicides in forest practices.

G. L. WAXLER ("Specific-Pathogen-Free and Germ-Free Animals in Research") is associate professor of pathology at Michigan State University. He obtained his D.V.M. degree in 1953 at the University of Illinois and his Ph. D. at Michigan State in 1961. Prior to joining the Michigan staff in 1957, he was engaged in private veterinary practice for 4 years in Illinois. Dr. Waxler's chief research interests are in swine diseases and the effects of enteric bacteria on gnotobiotic pigs. He is a member of the American Veterinary Medical Association and the American College of Veterinary Pathologists and the International Academy of Pathology.

Presenting an Oral Report

Most scientists and engineers eventually have to face the task of presenting an oral report of some phase of their work to a group. This report may be very informal; it may be part of a formal program at a national or regional meeting. Regardless of the occasion, the presentation demands special techniques to make it successful. Most of these techniques are easy to adopt.

Manuscript

A manuscript intended for oral presentation should differ in a number of ways from one intended for the printed page. Wherever possible, sentences should be shorter. If you find you cannot shorten a long sentence, use a series of periods . . . . . to separate clauses. This will force you to pause and will improve clarity and understanding. Use short familiar words whenever you can. Perhaps some words are difficult for you to pronounce. Use substitutes. If your manuscript contains foreign names or terms, follow them with phonetic pronunciations. Ex: *dugong* (DOO-gong). Read from a typed manuscript, double-spaced or triple-spaced. Underline in heavy pencil the words you want to emphasize. If a paragraph contains a list or series of appositives, use the 1,2,3 approach. Listeners appreciate this courtesy. Condense as much as possible.

If your paper deals with a number of subtopics, it is imperative that you use adequate transition between topics to promote instant understanding. On the printed page, headings usually provide enough transition between topics. But an oral report, naturally, loses this aid. A change of voice pitch helps show transition; a statement or two about the new topic—together with the voice change—should make listener comprehension much easier.

Delivery

Unless your report contains some astounding new information, poor delivery will practically guarantee unfavorable audience response. Fortunately, good platform habits are not difficult to acquire. Ask your colleagues to give you constructive criticism; take your faults seriously.

Whether you read from typed pages or speak extemporaneously from notes, it will pay you to rehearse. If you speak before groups infrequently and if you suffer from stage fright, by all means read a prepared manuscript. Time yourself. Remember that it takes longer to read a paper before an audience than it does to read it aloud to yourself. Keep within your alloted time limit.

With practice, you can learn to read before an audience in such a way that it won't sound as if you're reading at all. Speak slowly. Try to adopt a conversational tone. Know your material so well that you can look at your audience as much as you look at the paper. Your eyes can save you from becoming a bore. If you are using slides, don't make the common mistake of looking at the screen instead of the audience.

Voice

In reading manuscripts, inexperienced speakers often make two mistakes—they read too fast and they speak in a high-pitched, unnatural tone. Relax. Imagine you are chatting to a friend. Force yourself to pause often. Remember that you are trying to share ideas with your audience; most listeners will not even notice pauses that may seem interminably long to you. But they must be in the right places. Advance marking of a manuscript will give you the opportunity to make the most of this device.

Learn how to use "peaks" and "valleys." These are the ups and downs in the voice pitch. Listen to radio and television announcers; notice the absence of a monotonous tone. Many adults, in an effort to sound authentic at the speaker's platform, seem to lose any freedom of melody they may have possessed as children.

Microphone Technique

If you are speaking over a public address system, there are a number of little tricks you can use that will help to give you the mark of a professional.

If you are the first speaker, don't "test" the microphone. Assume that the system is turned on and that someone is monitoring it. But if you feel you must make sure, a simple adjustment of microphone position, or lightly tapping it, should let you know if it is working.

Respect the microphone for what it can do for you. It aids in projecting your voice to the audi-

ence. If you wander away from it, or weave back and forth, it ceases to help you. Except in large auditoriums, a public address system serves only as an aid, which means that you have to speak up and speak distinctly. Rarely can you expect it to carry the whole burden of projecting your voice. Don't fiddle with the microphone or the microphone stand. This may annoy or distract an audience.

Unless you are an experienced speaker and know the power of your voice, don't decline to use the microphone. If it's there and hooked up, chances are you need it.

If you have had little experience in speaking over a public address system, it is normal for you to feel somewhat nervous before you begin to speak. The moment before you begin to speak, take a deep breath, hold it briefly, and then exhale slowly. You will find that this trick helps to relax you. Above all, don't be afraid of your own voice when you hear it amplified. Your listeners are interested only in hearing your message. Make sure they do.

Visual Aids

Good visual aids can add immeasurably to the effectiveness of an oral report. However, no attempt will be made here to discuss in detail the preparation of such aids. This is an art in itself and deserves the attention of a professional visual aid specialist. Nevertheless, the author of a paper can set certain standards and adopt practices that will help assure a satisfactory presentation.

- Keep slides and charts simple; eliminate extraneous material that might confuse the audience.
- Make sure that the entire slide or chart is legible to those in the back of the room.
- Title and label each piece of visual aid material; take a few minutes before the meeting to see that they are arranged in proper order.
- Don't show a chart or slide until you are ready to talk about it.
- If possible, avoid handing out any materials before or during your talk.—W. W. K.

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"The ills of a society might be cured
if men could grasp a rationale of society
as clear and cogent as a geometer's proof."

THOMAS HOBBES
1588–1679

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